THE PRINCIPLES AND PRACTICE OF DENTISTRY

INCLUDING

ANATOMY, PHYSIOLOGY, PATHOLOGY, THERAPEUTICS, DENTAL SURGERY AND MECHANISM.

BY

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CHAPTER X.

ARTICULATION.

The term Articulation, as used in Dental Mechanics, comprehends several distinct operations, implied in the use of the terms (1) Articulating impressions; (2) Articulating plates; (3) Articulating models.

In many partial tests it is best, after fitting the swaged plate to the mouth, to take a wax impression with the plate *in situ*. This gives the precise relation of the plate to the adjacent teeth; and upon application of a model of the lower jaw, it gives the relation of the plate to the antagonist teeth. This and all other impressions of the *relation* of plates to the teeth or to each other in the mouth we call articulating impressions.

A base plate becomes an articulating plate when the articulating rim is attached which has the impress of its opposite rim or teeth. In swaged work it is the gold plate itself; in plastic work it is some temporary plate of tin, lead, or gutta percha.

The articulating models make up what is technically called an "Articulator," of which there are many forms; all, however, comprehended under three varieties: (*a*) Those wholly of plaster poured into the articulating plates. (*b*) Those in which the model portion is poured into the articulating plates, but the back or hinged portion is metallic. (*c*) Those in which the original models are set into the articulating plates, and some complicated metallic articulator adjusted to them. Each of these classes have special advantages adapting them to various exigencies of practice.

Whenever, in partial cases, there are three points of contact sufficiently apart to give firm antagonism, Prof. Austen's plan was to take an impression of the lower teeth; this gives a model which antagonizes perfectly with the upper model, and makes the articulator without further trouble. This plan, specially applicable to vulcanite work, is adapted to swaged work by taking the articulating impression described in the second paragraph of this chapter. Such articulators require no backward extension or hinge, because the articulation is determined by the articulating cusps of the teeth.

In partial cases, where there are only one or two points of antagonism, and where, consequently, the opposition of the corresponding teeth would be uncertain, the necessity exists for some third point of support. This is best given by a backward extension of the model, so as to permit motion of the two halves of the articulator, somewhat resembling that of the natural jaws, though many partial cases do not require such an extension. In putting this wax rim on the

plate it is better in all cases to trim it, as is done for full upper sets; but where there are remaining teeth the antagonism of these determines the proper closure of the mouth, and this is not essential. The plate and adherent wax are placed in the mouth; the patient is then requested to close the mouth naturally, imbedding the teeth of the lower jaw in the wax. While the mouth is thus closed, the wax on the outside of the teeth and alveolar ridge is pressed closely against them.

This done, the plate and wax impression are carefully removed, filled with plaster, and placed on a piece of wet paper, with the wax downward. The upper side of the plate is then oiled. As the plaster stiffens it may be applied until it is raised half an inch above the plate, and extended back of it on the paper an inch and a half or two inches. As soon as the plaster has set, its edges may be neatly trimmed; and at the back of the surface next the paper a deep transverse or T-shaped groove should be cut to serve as a model for the formation of a corresponding ridge on the half model with which this is to antagonize. This grooved surface must be coated with oil or soap water or varnish, or covered with a layer of tin foil or thin paper. Then partly fill the space inclosed by the wax rim with clay, putty, or wet paper, and pour on plaster to form the other half model. In running plaster into the wax impressions of the teeth, be very careful to avoid air bubbles and flaws, and do not oil the wax. After the plaster has set it may be trimmed as before directed.

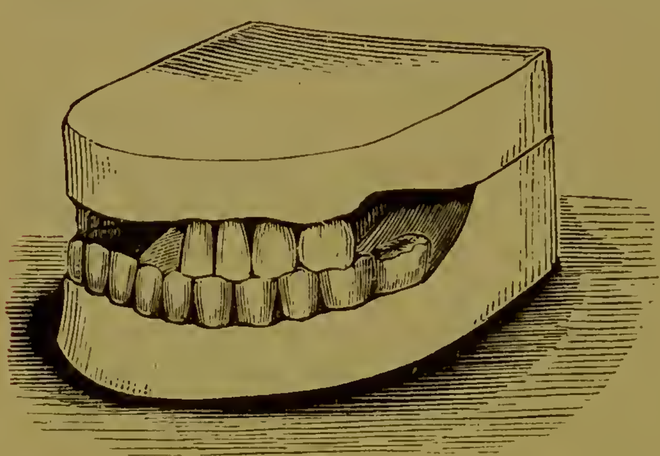

FIG. 965.

Another and often more convenient method is to take a strip of sheet lead one and a-half inches wide, and bend it to the required outline of the articulator. Pour this partly full of plaster, and set the plate, previously filled with plaster, upon it. Cut the grooves as before described, and pour the other half of the articulator. The lead rim saves much manipulation and trimming, which, in the other case, the plaster requires. When the half last made has become sufficiently hardened, the two pieces may be separated, after softening the wax in warm water, and the wax carefully removed. The model is then varnished, for greater comfort in handling, and when put together may present an appearance exhibited in Fig. 965.

The artist has failed in this, and in other designs of the plaster articulator, to represent the tapering shape which it is best to give to the back half of the models, for greater convenience of holding them while adapting the teeth. The fault of many plaster articulators is that they are too large and clumsily shaped. In any given case the proper distance of the groove or hinge is the distance from the patient's external auditory meatus to the line of the front teeth or alveolar ridge. The width and thickness of the articulator must vary with the size or depth of the mouth, avoiding any excess of plaster not necessary to give requisite strength.

For a full upper set, or where two or more remaining molars have no antagonism, it is a very common practice to place on the plate a roll of wax sufficiently large to receive the imprint of the lower teeth, and to prevent these from closing too far by the insertion of a piece of wood buried in the wax and projecting at the median line. The closure is better arrested by two lumps of sealing wax attached opposite the bicuspids, and trimmed to the required length before putting on the wax. But the articulation ought to determine other points besides the single one of space. Hence the antagonizing plate should be made by adjusting a rim of wax corresponding in width to the length proposed for the artificial teeth, and trimming it until all the teeth in the lower jaw touch it at the same instant. Instead of wax, a rim of gutta-percha may be used to represent the required length and external fullness of the teeth. When this is satisfactorily adjusted, a small rim of soft wax is placed upon the wax or gutta-percha, and the mouth closed as naturally as possible until the teeth touch the latter. The gutta-percha can be readily trimmed with a sharp knife. Rims thus shaped give opportunity to ascertain, by the effect on the expression of the lips, etc., exactly what length and fullness of tooth suits the particular case. Gutta-percha is better than wax in arresting the closure of the teeth, and is decidedly best for the temporary articulating plates of plastic work; but the latter is more easily attached to a gold plate and is more easily trimmed. By making the wax cold, or by imbedding a small block of wood opposite the bicuspids on each side, with the grain of the wood running transversely, for easy trimming, the wax rim offers a firm resistance.

There is a tendency on the part of the patient to close the mouth to one side, and nearly always to project the jaw too far forward; it is impossible to close it behind the natural articulation. The simplest method for regulating this is to keep the body erect and throw the head backward, so as to make as tense as possible the throat muscles, which thus act as a bridle, and almost compel a correct closure of the mouth. It may also be done by careful observation of repeated

closures made by the patient while sitting in an erect natural position. The operator must avoid impressing upon his patient the necessity for an easy natural closure; such directions invariably defeat their object. Of course, these trials are to be made before attaching the soft wax which receives the impress upon the final closure. A vertical median line, traced on the wax, is of service in observing the articulation and in the subsequent adjustment of the artificial teeth. Fig. 966 represents such a rim with its original fullness cut away.

For a double set of artificial teeth the following method of articulation is often adopted. After having accurately fitted both plates, a rim of soft beeswax is placed between them, about an inch and a quarter in width. A piece of wood, exactly corresponding in width to the proposed length of the upper and lower central incisors, is passed through the wax between the plates at the median line; or, still better, one piece on each side between the bicuspid part of the plates. The whole is now placed in the mouth, and each plate accurately adjusted to the alveolar border. The patient is then directed to close the mouth until the plates are brought in contact with the edges of the interposed piece of wood. This done, the plate, wax, and wood are together removed from the mouth.

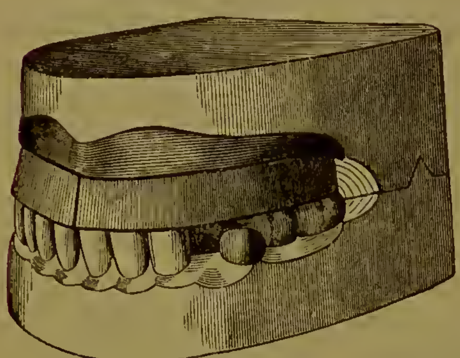

FIG. 966.

But a far better method consists in placing a rim of wax or gutta-percha on each plate, giving the length, outline, and fullness respectively designed for the teeth of each jaw. The two plates are put in the mouth, and the jaws are carefully closed; if the rims of wax touch at any one point sooner than another, the plates are removed and the wax trimmed; this operation is repeated until the two rims of wax meet all the way round at the same instant, and give the proper contour to the cheeks and lips. The median line is then marked, and the final closure of the mouth made with the utmost care, so that there shall be no lateral or forward deviation. The exact position being secured, the lower jaw is to be held with the left hand, while with the right some six or eight oblique indentations are made with a wax-knife across the line of contact between the two rims. Some fasten them together by a warm wax-knife or by pins or by small slips of brass plate warmed and forced into the wax. The pieces are removed jointly or separately from the mouth; if separately, they can, by the aid of these marks, be accurately readjusted.

From these articulating plates a plaster articulator (Fig. 967) is

made substantially in the manner described for a partial case. If the precaution is taken to fill the space within the wax rims and between the plates with paper pulp, it is not material which half is filled first. Usually the lower-jaw model will be thickest, and in this, made first, it is best to cut the grooves. Fig. 967 represents a plaster articulator with the plates removed, in which figure, from neglect of this point, the thin upper half is much weakened by the V-shaped cut.

Dr. J. G. Templeton suggests the following method of properly articulating a set of teeth: "Having to make a full upper set of teeth, we will suppose the impression and model to have been made in the usual way. Take modeling composition, and make of it a trial plate (a gutta-percha plate will answer also). It should accurately fit the model. Melt a little wax around on the ridge, then press a roll of softened wax on that, and trim to what is supposed to be a sufficient

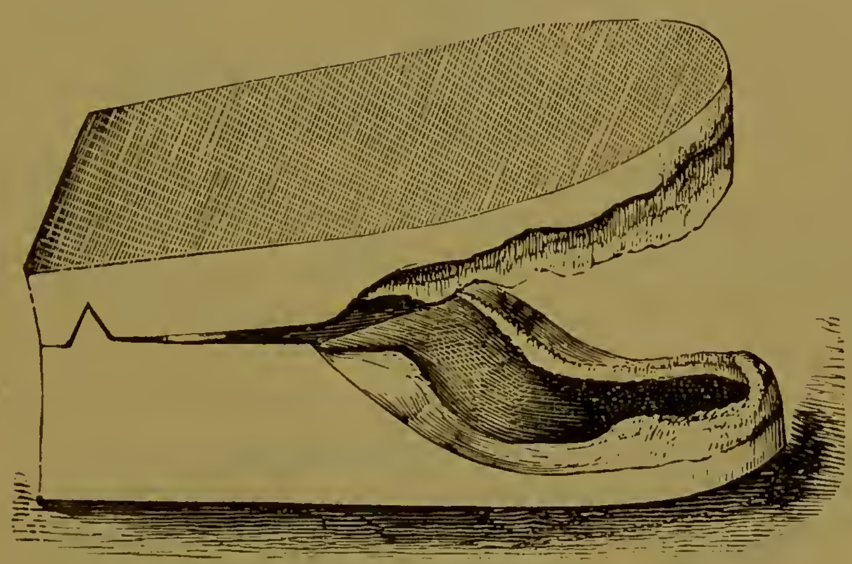

Fig. 967.

length, then try in the mouth and carefully trim the lower edge to the proper length for the teeth; if it is not, either add or cut away until the wax represents the proper length of the teeth. This wax should be so cut on its articulating surface that all the lower natural teeth will strike it at the same time when tried in the mouth. Now remove and soften the articulating wax surface just a little over the flame, then replace in the mouth, and do not let patient bite into it until you have the head drawn well back so as to put the anterior muscles of the neck on a stretch; then have the patient bite a little on the wax just to get an impression of the cusps and cutting-edges of all the lower teeth. Next take an accurate impression of the lower teeth, from which make a plaster model, which will fit into the slight impressions of the teeth made in the bite taken, and then place the whole on any good articulator which can be set to maintain the relative positions. Remove the

bite, and you are ready to set the teeth to a correct articulation, and if all has been carefully done the teeth will come together properly without any subsequent grinding.

"For a double set (upper and lower) make trial plates of modeling composition to take the bite on, putting a piece of rather stiff wire in the lower one to stiffen it. Wax the ridges as previously prescribed. Place a roll of softened wax on the upper trial plate, place the lower trial plate in the mouth, being careful to see that it is in its proper place, and hold it there while putting in the upper plate with the wax on it. Do not allow the patient to bite until the head is drawn back as far as you can get it; then tell the patient to bite, and keep the jaws closed until with one finger the wax has been well pressed on to the trial plates. Mark the center or median line on the wax. Have patient close the lips, and then take a small, straight instrument and mark on the wax the height of the lower lip. This mark should extend from one angle of the mouth to the other; you then have the line of fissure or line of lip-closure, in other words, the height of the lower lip and length of the upper, to serve as a guide in making the wax models. After thus taking the bite, place each of the models in the bite so obtained, and fasten in any good articulator; then prepare corresponding wax models, which should be tried in the mouth to verify their correctness. They should come together in the mouth the same as on the articulator, and if they do not they should be made to do so before proceeding further. Take pains to be satisfied that the wax models are correctly adjusted and give a natural expression to all the facial features, observing that the lower third of the wax model is in proper proportion or length with the upper two-thirds, and be sure to produce the proper fullness over the region of the upper cuspids to give as near as possible the natural contour. Then take the upper and lower plaster models off the metal articulator, and make a plaster extension to the back part of upper model, on which place the wax models, which have been marked while in the mouth so that they can be put in the same position out of the mouth. The lower plaster model is placed in position, and a plaster extension added to fit to that of the upper plaster model. After separating these, the lower wax model is placed on the lower plaster model, and the inside space filled with wet paper, and plaster is poured over all to make the lower articulating plate, to which the lower teeth are to be set. Next place the upper model in position, and set the upper teeth to the lower ones which have just been set to the lower articulating plate, and when ready for flasking, if for vulcanite plates, saw off articulating ends. Always set the lower teeth first."

Partly to save plaster, but chiefly to permit modification of the

articulation where inaccuracy is suspected, quite a number of metallic articulators have been recommended. One of the first contrived for this purpose was by Dr. Thomas Evans, of Paris, and made of heavy brass wire.

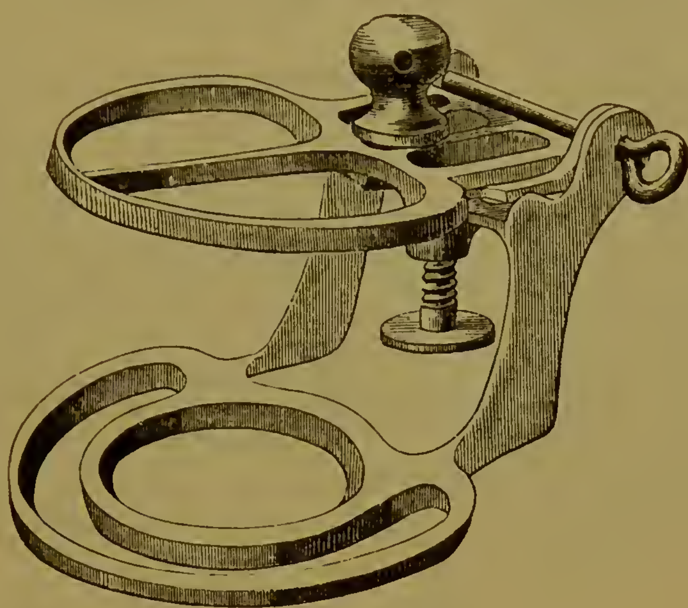

FIG. 968.

Fig. 968 represents a very convenient form of metallic articulator. But in using this and every similar contrivance the operator should remember that facility of changing the articulation, after the guiding

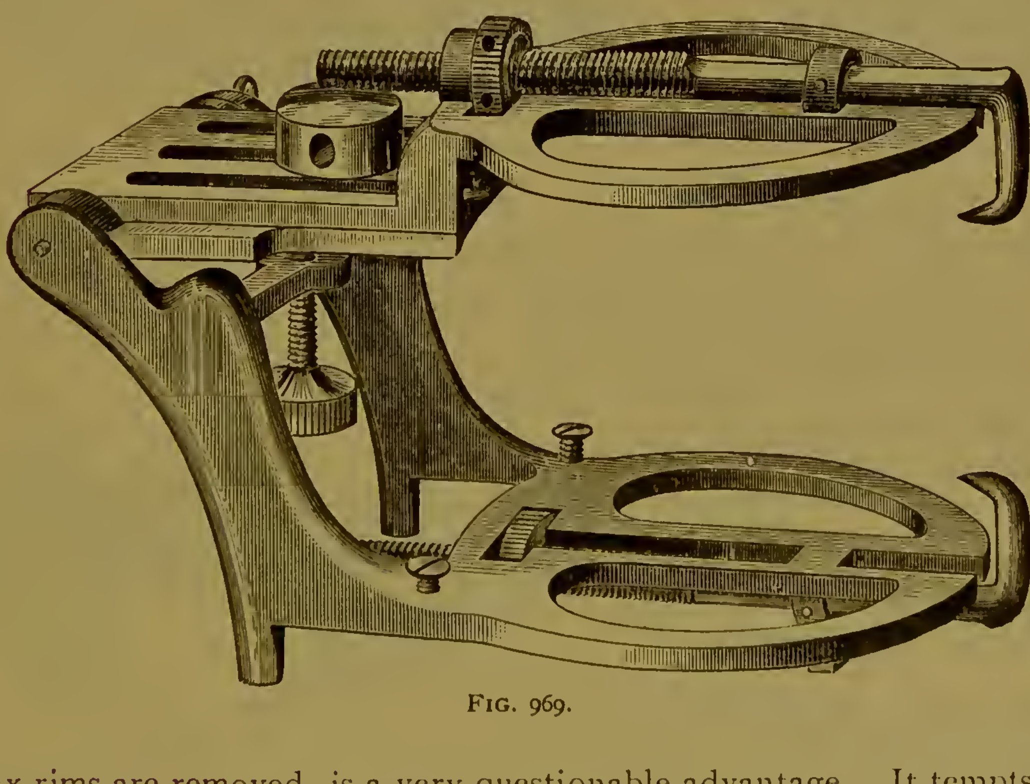

FIG. 969.

wax rims are removed, is a very questionable advantage. It tempts to carelessness in articulating. Moreover, if the width of space or other relation of the parts is such as leads to suspicion of inaccuracy, any change of articulation is, at best, a sort of random guess-work. The

most certain correction of surmised error is, undoubtedly, to take the articulation anew. Hence some prefer the old-fashioned plaster articulator, with its unaccommodating fixedness, that neither offers a premium on carelessness, nor puts the careful workman at the mercy of some loose joint or screw.

There is another class of articulators more complicated than the above, which are very useful in those cases where the original models are used, instead of special models cast in the articulating plates. Fig. 969 represents an articulator devised by Dr. J. B. McPherson, the valuable feature of which is the clamping fixture for holding the plaster model. The danger of breaking frail models in removing them from the articulator is overcome, as they can be removed by simply loosening the clamp. It has also a lateral movement resembling that of the jaw.

Dr. W. Storer How suggests the use of soft yet sufficiently stiff and thin metal plates for securing an exact tooth-length and a correct articulation, which he terms "true bite-plates." His description of these plates and method of using is as follows:*—

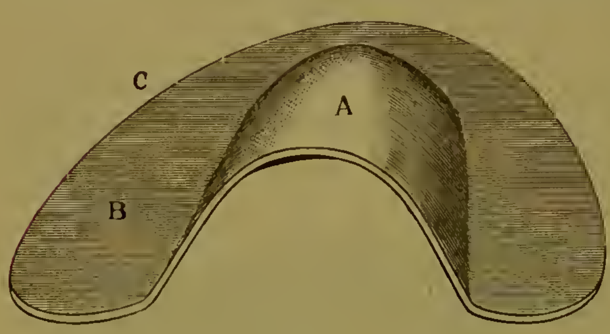

Fig. 970.

"In Fig. 970 is seen an upper bite-plate of suitable thin metal, having a palatal portion A, a plane portion B, and a contoured edge or border C. When a full upper denture is contemplated, the bite is at once taken by placing on the bite-plate, Fig. 970, a sufficient quantity of warmed beeeswax to secure a completely good impression, and at the same time afford material for modeling the labial and buccal surfaces in a suitable manner to produce the proper facial expression.

"The bite-plate here exhibits its novel and useful functions in enabling the dentist to readily lengthen or shorten the bite, and also adapt the bite-plane B to the lip-line, as well as to the occluding lower teeth. When this has been carefully done and the mass removed from the mouth, the appearance will approximate that of Fig. 971. If the bite then requires an increase of length, the bite-plate is

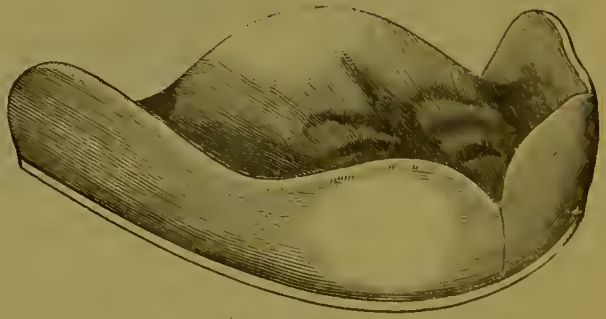

Fig. 971.

* *Dental Cosmos.*

held a moment over the Bunsen flame, when it will fall on a paper napkin held in the hand. It is then covered with a thin sheet of wax, replaced on the modeled wax, trimmed with the wax-knife along the contour border C, again put in the mouth, and conformably remodeled and readjusted. The quickly transmitted heat of the metal bite-plate permits facile changes in occlusive adaptation and contour, without disturbance of the fit of the impression portion of the wax, an advantage of real consequence and value.

"If upon further study it is desired to shorten the bite, the mass is removed from the mouth, the plate quickly warmed over the Bunsen flame, all replaced in the mouth, and the patient instructed to close the teeth firmly on the bite-plane, which, while accurately maintaining the plane of the occluding teeth to which it has been conformed, will at the same time cause the softer wax immediately in contact with the plate to gradually yield until the bite becomes suitably shortened.

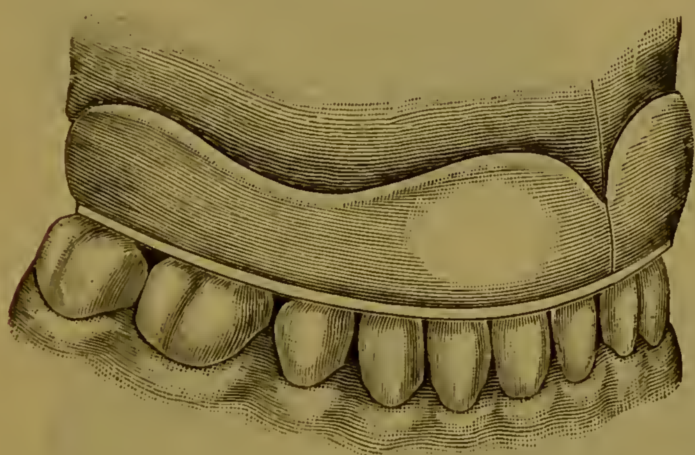

FIG. 972.

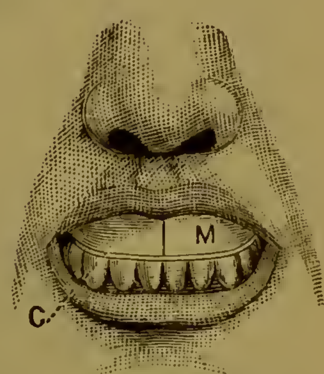

FIG. 973.

"In this connection it is important to note the functional difference of this metal bite-plane from the common wax plane, which yields and is indented by any considerable pressure of the occluding teeth; whereas, in the present instance, so soon as the wax has cooled to a slight stiffness, the patient is directed to press the teeth hard on the bite-plate (see Fig. 972), and the result is a bite-gauge identical in length with that which the finished denture will have under the ordinary pressure of the closed jaws. Many of the usual disappointing discrepancies between the common soft wax bite-gauges and the resulting defectively articulating dentures may now be avoided.

"The smooth and hard surface of the bite plane B fixes a constant and firm limit to the bite-length while allowing the utmost freedom of lower-jaw movement in occlusion during the adjusting and modeling processes to secure a natural oral and facial expression, with a proper lip line as indicated in Fig. 973. This having been accomplished, a

roll of warmed wax is placed on the under side of the bite-plate, which is replaced in the mouth, and the patient, while the previous process was going on, having been instructed and practiced in the correct manner of closing the jaw, the head being thrown back to bring the

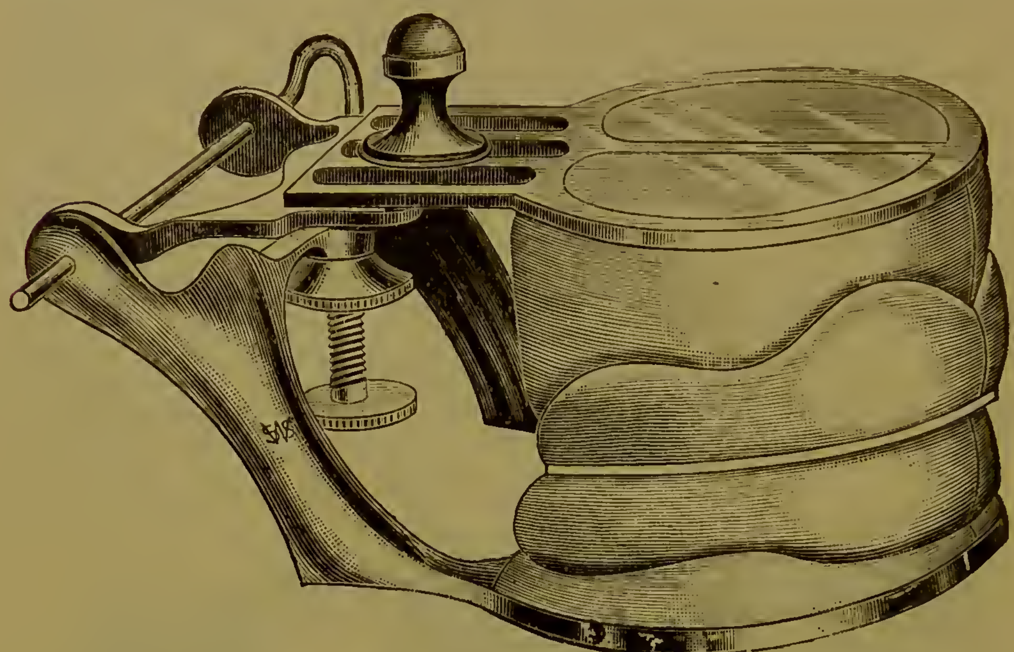

Fig. 974.

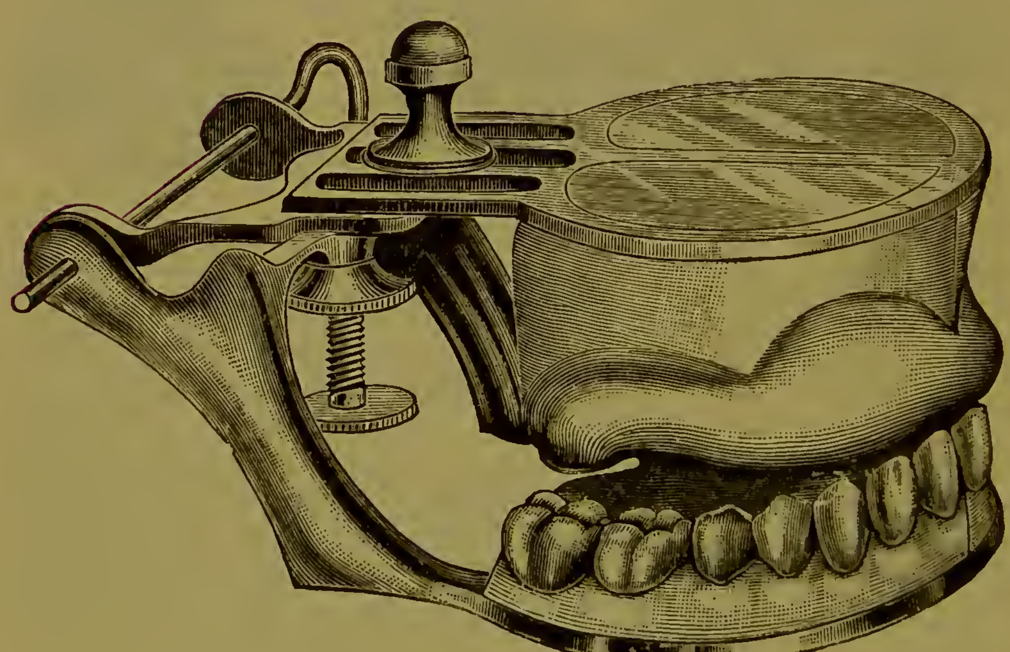

Fig. 975.

face horizontal and the jaw held as far back as possible, the teeth are pressed through the wax on to the bite-plate, and kept there while with the finger the labial and buccal portions of the soft wax are pressed in upon the natural teeth. The mass is then carefully removed from the

mouth and kept in safe readiness for transfer to the plaster model when obtained from the plaster impression, and it is unnecessary to dwell upon the advantages of securing a certainly correct bite at the time of the sitting secured for taking the plaster impression. Fig. 974 shows a bite thus taken and transferred to the model set in an articulator, and Fig. 975 represents the correct bite so obtained. This novel bite-plate provides for the taking of a very short bite, as shown in Fig. 975. In fact, the bite-plane B may rest directly upon the gums, and the under teeth strike the plate, yet the rigidity of the metal plate is such that the wax impression and modeling will not warp in the adjusting, shaping, and removing manipulations; whereas, by the old mere wax methods, a trustworthy very short bite is impracticable.

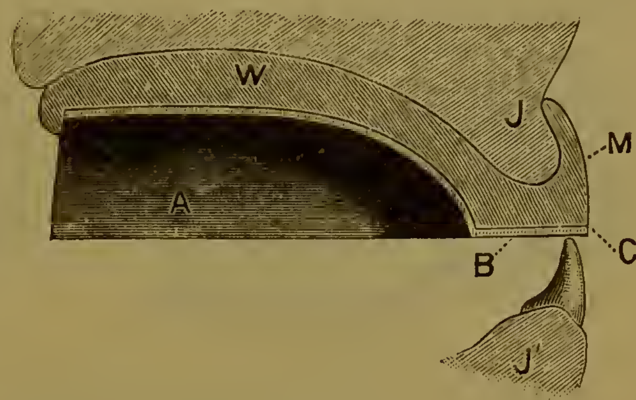

FIG. 976.

"Fig. 976 exhibits a median line section exemplifying the relations between the bite-plate A, B, C, the wax W, the modeling M, the upper jaw J, the lower jaw J^1, and the occluding lower teeth. Obviously, by simply first warming the bite-plate and then while in the mouth sliding it suitably forward, the contour modeling may be done to produce a result like that of the median line section, Fig. 977. In any given case the bite-plate border C can be easily cut or filed to suitably modify its contour to the desired configuration of the modeling, although it is best to have at hand several sizes of the bite-plate to use without delay for adaptation.

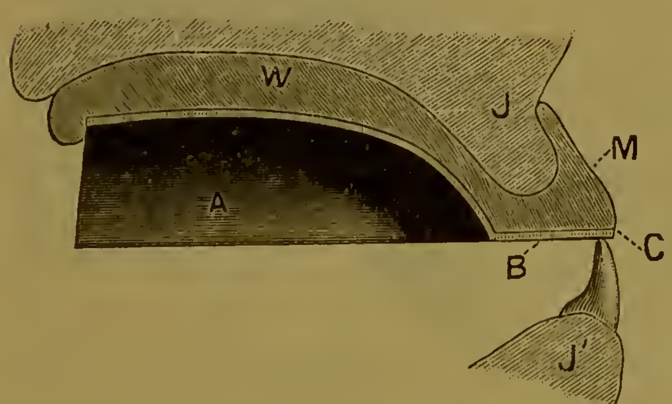

FIG. 977.

"By cutting away the wax W to expose the upper anterior gum G and ridge-crest from cuspid-place to cuspid-place, as shown in Fig. 978, the space between the bite-plane border C and the ridge-crest may be accurately gauged to determine the availability of artificial teeth having cross-pin, or up-and-down-pin bite length; it being a matter of importance at the outset to decide the question of permissible bite-

space between the gum crest and the down-pin border of the teeth-backs. The overbite or lap of the upper oral teeth over the incisive edges of the lower teeth may then be provided for by means of some softened wax on the under side of the bite-plane, modeling some wax over the anterior gum and edges of the lower teeth, as shown in Fig. 979.

"Bite impressions for partial dentures, however irregular the jaw surfaces or occlusive dispositions, can be most conveniently and correctly produced by means of the modified bite-plates herein shown and

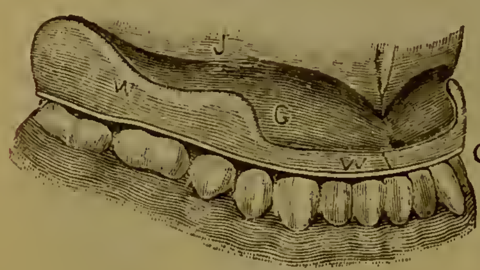

FIG. 978.

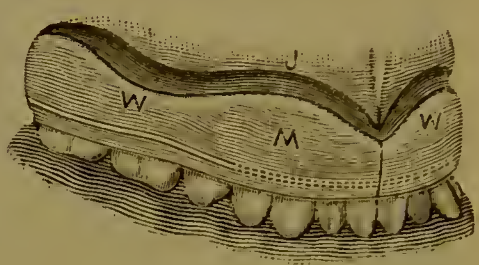

FIG. 979.

described. In some instances modeling compound, plaster, or moldine may be advantageously employed instead of wax.

"For partial upper dentures, sections of the bite-plate are with plate-nippers cut out, as at EE, Fig. 980, and the bite taken in the way previously described.

"The lower bite-plate, Fig. 981, is of like character with that of Fig. 970, the lingual portion D being designed to approximate the

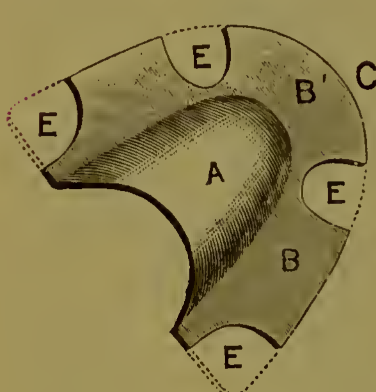

FIG. 980.

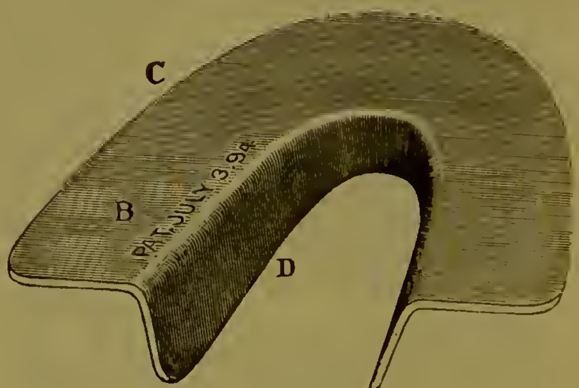

FIG. 981.

lingual conformation of the lower jaw, while the bite-plane B and contour border C have the bite-taking functions of the upper bite-plate. For partial lower dentures, sections may be cut out, as at EEF, Fig. 982, to permit the passage of the remaining natural teeth through the bite-plate, the intermediate planes of which can be shaped to conform to any plane of the occluding upper tooth or teeth.

"When either jaw is a very flat one, it is best to take first on the bite-

plate a good impression in wax, and then with a spoon spatula scoop out about an eighth of an inch deep over the surface of the impression, smear over it some rather thick mixed plaster, and take another complete impression. This, when allowed to get quite hard and suitably trimmed at its borders, may be often replaced, and readily retained in the mouth during the modeling and adjusting process requisite in obtaining the bite by the methods already described. In fact, this is the preferable procedure for bite-taking in the greater number of full-denture cases, since the plaster contact with the jaw is unvarying and retentive, while the bite-plate is adjustably movable on the intermediate modelable wax. There is, furthermore, the certainty that the plaster bite impression will fit the plaster model; in fact, it may sometimes supersede the plaster impression if found in some particulars the better. Thick-mixed plaster may be piled on the

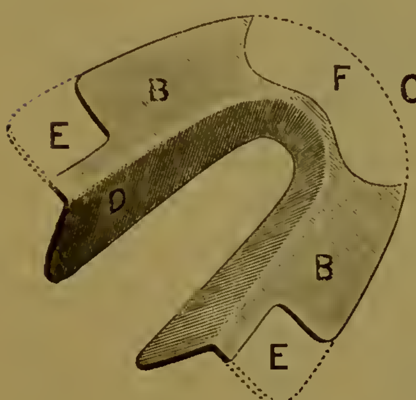

FIG. 982.

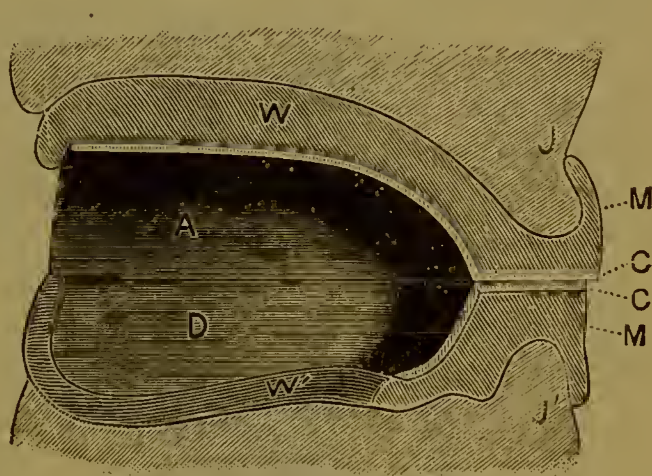

FIG. 983.

under surface of the bite-plane, and the occluding surfaces of the under teeth be perfectly copied for reproduction in fusible metal if desired.

"If the maxillary vault is a very low one, an upper bite-plate with its plane B resting on a flat block may be struck with a hammer on its arch A, Fig. 970, to suitably depress it to conform to the low vault. To suit a narrow high vault, set the buccal edge on a block or anvil and strike it with a hammer on the opposite edge to contract the wings and raise the arch A.

"In taking the bite for a full denture, the upper and lower bite-plates are used as already described, and the facility with which the modeling, contouring, lip-line, and relative upper and lower teeth lengths may be determined will agreeably surprise experienced prosthetists accustomed to the old wax-model methods. The upper and lower metal bite-planes, during the process of adjustment, perfectly maintain the bite length, yet slide freely upon each other during the mas-

ticatory movements of the jaw requisite in repeated trials to determine the correctness of the modeling and the bite-lengths. When that has been satisfactorily accomplished, the patient is instructed to properly close the jaws and hold them firmly closed while the median line mark is made, and the lips on either side held apart while the usual cross-lines are scratched over the modeling and the two bite-plate edges somewhere near the molar regions on both sides.

"Both models are then removed, the bite-planes dried, slightly warmed, placed upon each other so that the median line and scratched marks shall exactly coincide and be held so, while with a stick of melted hard wax the inside edges of the bite-planes are stuck fast to each other. The correctness of the bite may be verified by replacing the united bite-plates in the mouth, distending the lips and cheeks with the forefinger to free them from entanglement with the plates, and making careful renewed observations to be sure that the bite is correct. The median line section, Fig. 983, shows such a bite.

"In the duplex bite-plate, Fig. 984, the two plates, Figs. 970 and 980, are made as one; and with a full understanding of the processes previously described, it may be in like manner used to take the bite for a full upper, or full upper and lower denture, as the case may be, Fig. 974 serving as an example of the taken bite in either case.

"The duplex bite-plate has an occasional supplemental use for taking simultaneous impressions of the teeth in both jaws for regulating purposes; when it is desired, for instance, to make a vulcanite or cast-metal plate, a portion of which is to cap the molars or other teeth. In such a case the bite-plane is to be cut away to allow the passage of the anterior teeth, leaving such parts of the bite-plane as may be required to rest upon the teeth which are to be capped. The wax on the upper and under side of the remaining portions of the bite-plane will insure in the articulator models a representation of the occluding surfaces in their exact relations to each other, and separated by the desired thickness of the vulcanite caps of the regulating fixture.

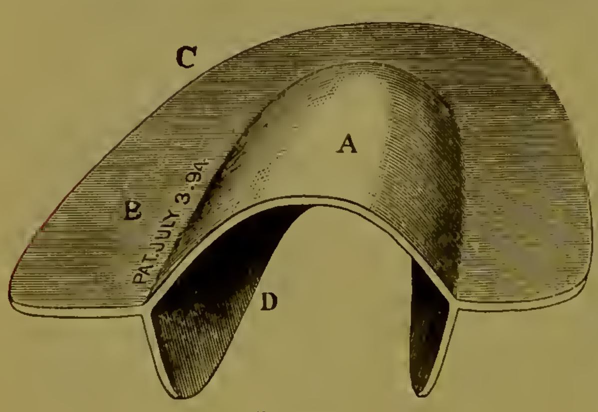

Fig. 984.

"In some instances, as when the vault is very high, the central part of the palatal portion A is slit and bent wide open, or with plate nippers suitably cut to allow the pressing up of the wax by the forefinger, to get a good impression of the deep vault.

"'These bite-plates provide for, and emphasis is laid upon the importance of procuring, a complete and perfect impression, which will fit the plaster cast taken from the plaster impression and thus insure the correctness of the bite as reproduced on the articulator. (See Fig. 975.) In some instances modeling composition is used instead of wax. In every case the tendency to redundancy of labial and buccal material in the modeling is to be thoughtfully avoided, as may well be done since the good palatal fit will serve to retain the plate even when the labial part of the maxillary ridge is not covered by the modeled wax.

"It is best to first take the bite, and follow with the impression, which is usually taken in plaster and attended with more or less discomfort to the patient.

"Not the least of the notable excellences of the new bite-plate is the

FIG. 985.

certainty that after the modeling has been done (see Figs. 972 and 973), the patient will bite through the soft under-wax until the teeth strike and are stopped by the bite-plane, thus invariably and accurately gauging the teeth-length. Indeed, both the means and the methods are submitted in the confidence that time and practice will insure their general approval and adoption by the profession."

A further series of bite-plate exemplifications following the above, and relating to the adaptation of the bite-plate to partial dentures, are as follows:—

"Take, for instance, a case like that of Fig. 985, the superior cuspids only remaining. A sheet of thick tin foil, or of pattern tin, is to be cut to the outline of an upper bite-plate (Fig. 970), placed in the mouth, and with the forefinger rubbed on to the gum ridge and around the cuspids to show their relative positions. This rude pattern laid

on an upper bite-plate will indicate the points to be cut out with plate nippers, as at EE, Fig. 980. The bite-plane B may be sheared to shape, and the bite-plate by repeated trials in the mouth be quickly prepared to receive the wax for obtaining the preliminary bite-gauge as shown in Fig. 986. This, when removed from the mouth, will

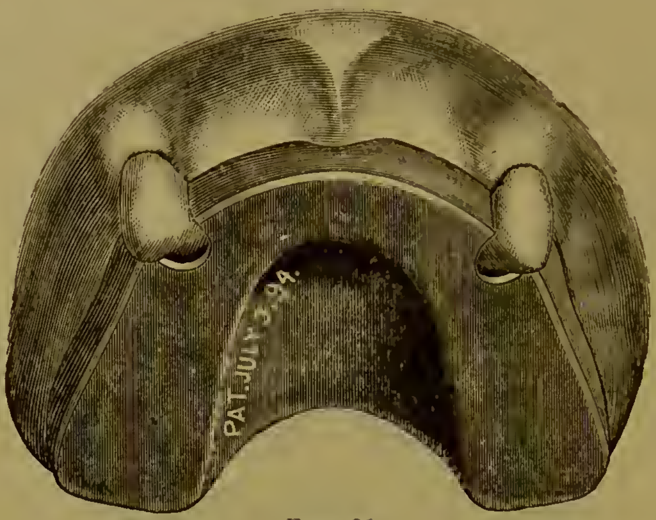

FIG. 986.

appear as seen in Fig. 987. When the additional wax for modeling and contour has been supplied, the case will present the appearance illustrated in Fig. 988, the median-line mark shown being a transference from that of the plaster models after the bite had been taken (as described on page 886) and placed on the articulator as in

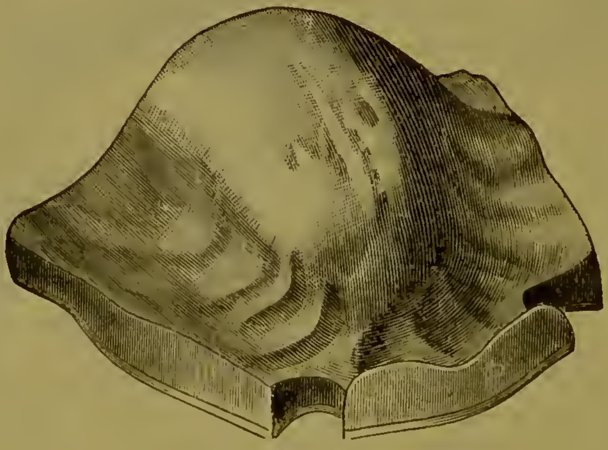

FIG. 987.

Fig. 974. Another instance is given in Fig. 989. Here the pattern-plate procedure is the same as above described, the bite-plate being readily fitted so that a piece of the bite-plane B, Fig. 980, shall enter every space that is to be occupied by an artificial tooth or teeth. There is no risk of overestimating the value of this adjunct of the

partial-denture process which results in an accurate bite ready for transfer to the model when obtained from the succeeding plaster impression.

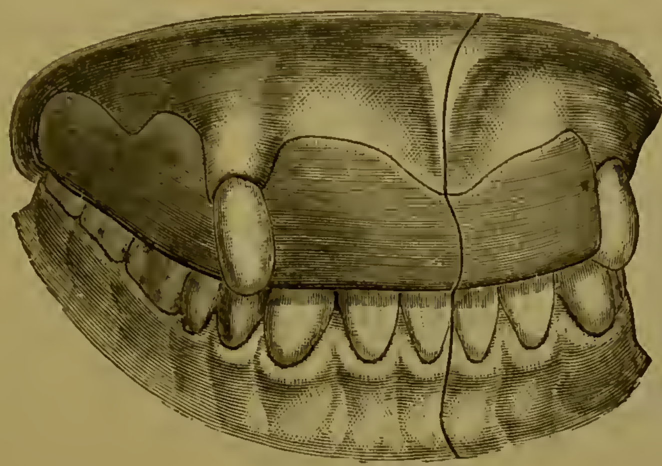

FIG. 988

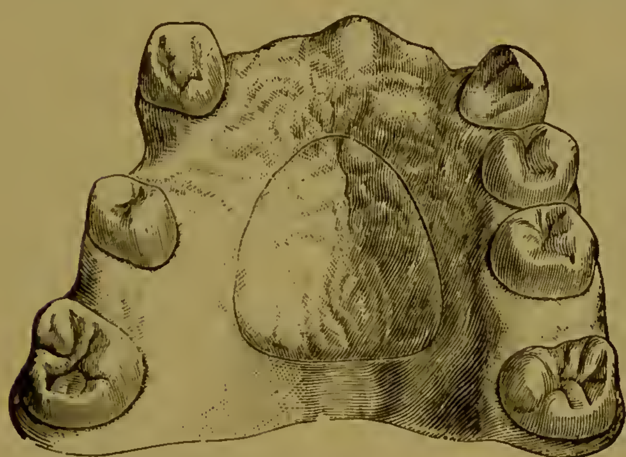

FIG. 989.

FIG. 990.

"Fig. 990 shows the taken bite with the labial and buccal portions of the under wax cut away to illustrate a defect in the common process of bite taking, not in fact manifest in the present instance, because the cuspids and other teeth compel a correct closure that is evidenced

by the thin films of wax at the points of occlusion contact seen on removing the bite, which is proven to be accurate when completed by the addition of wax over the labial and buccal surfaces of the lower teeth and a transference to the impression model on the articulator, the result being such as shown in Fig. 991.

"The common defect just referred to is the massing of too much wax on the under side of the trial plate, or bite-plate, and the consequent sliding forward of the lower front teeth as the inclined planes of their lingual surfaces are forced into the deep mass of wax, somewhat as is observable in the case illustrated by Fig. 990, and is made further obvious by Fig. 992. There is no practical need for a bite impression of the lingual surfaces of the lower teeth below the point P, Fig. 992, while on the other hand there is a serious reinforcement of the natural tendency to lower jaw protrusion in the act of desired bite-closure when the wax is massed as above mentioned. The new bite-plate permits the use of merely sufficient wax, as in Fig. 993, to reproduce the cutting-edges and cusps of the teeth without any aid to

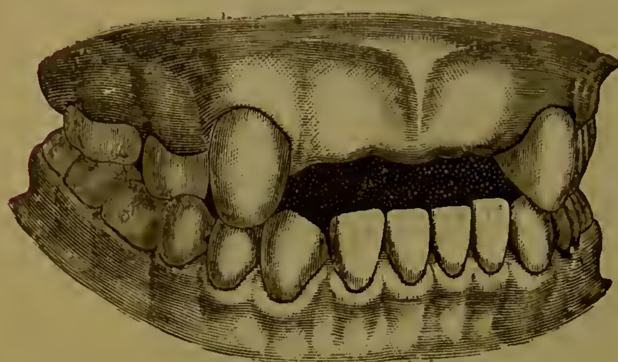

FIG. 991.

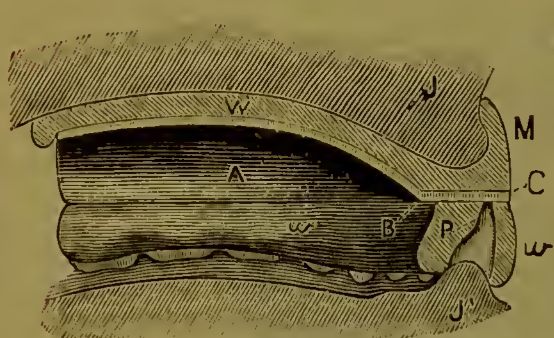

FIG. 992.

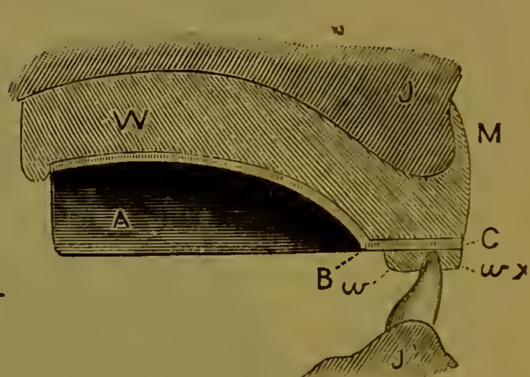

FIG. 993.

the protrusive tendency whatever. While the teeth remain closed for coronal bite reproduction, additional wax may be pressed on to the labial and buccal surfaces of the lower teeth to produce as perfect a representation as is shown in Fig. 991.

"It is hoped that the foregoing illustrations and descriptions will suffice as intimations of the manifold adaptation of the several bite-plate modifications to meet any and every case arising in practice, and

as affording ready means for the obtaining a correct bite prior to the taking of the usual plaster or modeling-composition impression, yet at the same sitting.

"The bite-plate method, while at the outset reasonably requiring the expenditure of some time and study, is still an economizer of both time and labor, inasmuch as it enables the dentist to meet the patient at the second sitting with a complete denture. In any case he may be ready with a trial-plate on which the teeth shall have been arranged and articulated so naturally that but slight alterations will probably be necessary. Especially will this be the case if instead of wax, as at *w*, Fig. 993, moldine shall have been used, and fusible metal poured in the coronal impressions to insure sharply-defined and non-abrasive cusps for accurate articulation."

Dr. W. G. A. Bonwill, who has devoted much time to the study of the geometric and mechanical laws of articulation, and devised an anatomical articulator (Fig. 994) in accordance therewith, treats this subject as follows:—

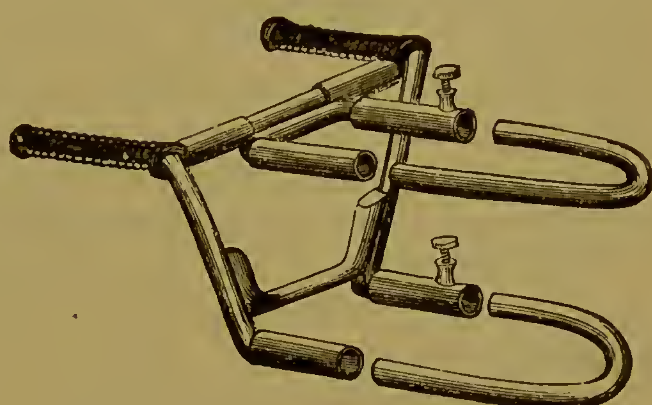

FIG. 994.

"We find from 28 to 32 teeth in each jaw, arranged in such a manner that no two strike directly against each other, but antagonizing in such a manner as to prevent the whole denture from becoming very irregular, which would be the case if striking one against another. By this arrangement, when one tooth is lost, the regularity of the arch is not interfered with. As necessary as this is in nature, it is not positively necessary to follow it in artificial work, although for the sake of harmony it should be done.

"It will be found in 95 per cent. of cases that the upper teeth project over the lower, and the depth of overbite varies as the depth of the cusps of the bicuspids are deep or shallow; and the ramus will be found to come upward and backward in relative proportion to the length of the cusps and the overbite.

"One point of very great importance has not been laid down in general or special anatomy—the peculiar tripod arrangement of the lower jaw, forming an equilateral triangle.

"From the center of one condyloid process to the other, four (4) inches is about the average; and it will be found that from this same center of the condyloid process to the median line at the point where the inferior centrals touch at the cutting edge is also four (4)

inches. It is strange it should have been overlooked; but it only shows, when studied in a geometrical and mechanical sense, the great wisdom in our formation. It varies slightly, but never more than one-fourth of an inch, which would make but a trifling difference in describing the arc of a circle. You will perceive that in setting your artificial teeth a one-fourth inch, the radius of the circle would not materially alter the articulation. Without such an arrangement the teeth would have to be flat on their grinding surfaces to admit of lateral movement. Besides, you would not have the beautiful and wise curvature at the ramus for equalizing the force applied to the teeth in all directions.

"Imagine the human jaw jointed at the pharynx, or as you see in the ordinary brass articulators. Do you suppose that there would be any greater wisdom displayed in such hinging or articulating a part destined to such varying motions and powerful wrenching force? No! We must see the true use or function of the jaw and the teeth, and the food destined for us, and how it should be comminuted; there is no chance work about it! There is law and order pervading every part; the jaw forms a perfect triangle for the purpose of bringing into contact the largest amount of grinding surface of the bicuspids and molars, and at the same time to have the incisors all come into action during these lateral movements.

"You will also find that from the cuspids the bicuspids and molars run in nearly a straight line instead of a curved one back toward the condyloid process, enabling them to keep the largest amount of surface always presented for mastication. Another thing which has never been explained by anatomists or naturalists is the law of the normal relation of the upper to the lower incisors. The normal jaw should overjet and also have a corresponding underbite. Without such a law the incisors would lose largely their functions, that of incising on the principle of a pair of scissors. Where the incisors strike directly upon each other the power to cut off food is very much lessened. The length of bicuspids and molars proves the law.

"Another unobserved fact where law is expressed, where there is an overbite and underbite, just in proportion to their depth will be the length of the cusps of the cuspids, bicuspids, and molars. By drawing two lines from T to F, Fig. 1001, or T to *a* and *e*, Fig. 995, we have the lengths of the cusps of the bicuspids, *b*, in the upper and *c* in the lower, and also *d*, the second upper molar. The depth of the underbite is one-eighth of an inch from the cutting edge of the inferior central incisor *e* to that of the superior central incisor *a*. Did the teeth extend as far back as A, A, there would be flat surfaces at those points. But in articulating artificial teeth, when the superior

second molar is reached, its distal cusp has to be raised from line T *e* to T *a*, Fig. 995, to allow the molar teeth on the opposite side, not in mastication, to touch, for merely balancing the plate, as Fig. 998, M, N, otherwise the second molars would be of no use in lateral movement, nor would the first molars. This curvature at the ramus (see Figs. 999 and 1000) commences at the first molar, although it shows itself slightly in the bicuspids. Practically it need commence at the first upper molar. This curve, then, will always be proportioned by the underbite at *a*, *e*. The length of the cusps on bicuspids will never be more than an eighth of an inch normally; the groove deeper than that would cut the palatal cusp off and make of it a cuspid. It would in reality be cut in twain. *This is another unobserved fact. It always has been and will be found in the archtype of human jaws.* So that when you see a first superior bicuspid, it can very well be told from the length of the cusps whether the jaw from

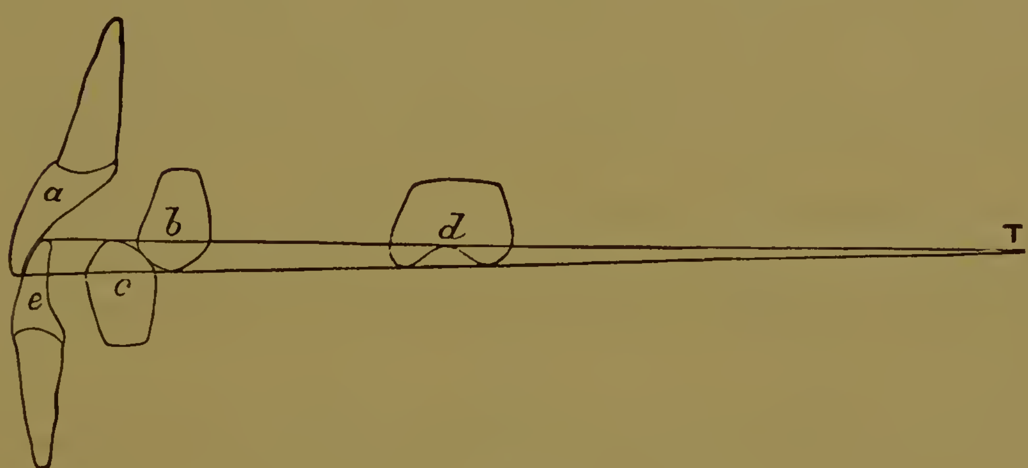

FIG. 995.

which it came had a depth of underbite of one-sixteenth of an inch or more. Where the teeth all strike fairly one upon the other and no overbite, then you have no occasion for cusps. If originally there they would soon be worn off from the abnormal articulation.

"This provision of articulation is most wise, carrying out still more fully the exact law by which the anatomical movements of the lower jaw for perfect mastication are governed. This movement we will find, in the artificial sets arranged upon this law, will prevent the plate from tilting. In the natural denture the incisors are really the first teeth to be arranged; though the first molars emerge first, to assist in the more perfect mastication of food and to keep the jaws at the proper distance. The incisors show a definite fixedness of purpose to arrange themselves after their typal shape, and to form the overjet and overbite at a given depth for the accommodation of the bicuspids and molars which are soon to appear, having cuspids of a definite

length, so that the law of articulation, which has been premeditated to a certain typal shape and construction, be carried out.

"It will also be found that the grinding surfaces of the bicuspids and molars have a typal shape—allowing them to meet with all their surfaces touching—for an express purpose, after a preordained and established law, from which the greatest area is gained for mastication; and that the inner cusps of the lower teeth are as necessary as the outer of the superior, when laterally moved. The law is still further carried out in the curvature at the ramus, from the second bicuspids to the third molar, to permit all the surfaces on one side to be in contact (Fig. 1000), while the other unused side is only partially so (Fig. 999). The nearly straight line of arrangement from the cuspids to the last molar is also in keeping with the underbite (Fig. 995).

"This triangle can only be found within a perfect circle in which you have the greatest breadth and area of surface. No other geometrical angle would have given such perfect beauty and symmetry to the face. The compactness brings the largest number of teeth nearest the center of motion. The double joint permits the greatest strength and the easiest lateral movement with the greatest range of this at the least expense of power and compass. It permits the largest number of teeth to antagonize at every movement, *and not least of all, this very triangle is the means by which nature develops the typal shape of the ramus, and of the formation of the jaws, the underbite, etc.*

"It will be observed that in making the lateral movement of the lower jaw to the left the condyle of the left side stands still or does not move backward, it merely revolves or rotates in the socket, which is but a trifle. The right condyle moves forward in the glenoid cavity fully half an inch, when at its farthest limit, causing the outer cusps of the upper, from the centrals to the last molar, to touch the outer and inner or buccal and lingual cusps of the lower on same side—the left (Fig. 1000, and J K, Fig. 998); and on the opposite side (Fig. 999, and M, N, Fig. 998)—the right—we find only the inner cusps of the bicuspids and molars of the upper to come in contact with the outer of the lower, and the centrals to the cuspids do not touch. And why so little surface touching on right side when the lower jaw is thrown to the left? You cannot masticate on more than one side at once, and when you throw the jaw to the left in the act of masticating, the food is upon that side, hence there is no necessity for the right side to have so much surface in contact. But why should it touch at all on the right? In order that the muscles on both sides should act equally, which could not be done if the teeth were not allowed to strike there, giving support to that side of the jaw, and equalizing the

force brought to bear upon that side, although no food be there. If there were no touching of the teeth on that side while mastication is going on upon the left side, there would result, as a sequence, that peculiar movement of the lower jaw at the condyloid process, which makes it difficult to place in teeth for the aged, or those even in early life who have lost all the grinders on one side.

"The form of triangle is necessary again for the purpose of giving the largest number of muscles a chance to act on both sides simultaneously and concentratedly, and thereby keeping the circle or arch of grinders down to their work, and equalizing the pressure on all sides. It enables the teeth on the side where the chewing is being done to arrange themselves when erupting, so that they will be very nearly in a line with the left condyle, which is now passive on this side, and forms one point of the dividers in forming the arc of a circle; and by this condyle being where it is—four inches from the other—the molars and bicuspids, as well as the central of that side, all come into the most perfect contact for chewing and incising, thereby carrying out this absolute natural law of the perfect adaptation of geometry and mechanics to her uses, and having no lost motion or function in any part.

"Again, the triangle gives us an extra motion forward, which brings the lower teeth in contact with the upper to incise or cut off food presented there. This could not have been with any other arrangement than the triangle. One central point at the pharynx or on the median line would have been a single swivel joint, and have brought the teeth across each other in such a way that as soon as any lateral movement commenced they would be drawn away from each other very rapidly, and but little surface be in contact. This triangle will enable you to get just the exact depth of underbite from the incisors to the last molar and the exact shape of arches; and particularly that of the ramus, which is not a matter of chance—neither is the length of cusps on the bicuspids and molars mere chance. The type has been preordained, just as the nose on your face, or the peculiar shape of the eye, or any other one part of the body. And you will find that where a superior bicuspid has a cusp of a given length, the overbite will be governed and ruled by it. It cannot be otherwise. If in the arrangement of the teeth in the human jaw no type or design were laid down in conception or embryonic life, what malformed creatures we should be, mentally and physically! *And it will be found that just in proportion as there is congenital insanity, or want of will or directing power, there will be a malformation of the teeth and their arrangement.*

"The next step is, now that we know the exact shape of the jaw

and its philosophy of form and functions, we must have at our command something so nearly approaching it that we can place our models upon it, and thus again restore nature's 'lost art.' I believe I have it here so nearly that it will be found to answer our most fastidious notions of setting by a system teeth on plate. The instrument is made of brass wire one-eighth of an inch in diameter (Fig. 994), and of such shape and movements as to correspond exactly with the mechanism of the human jaws. The base with its movements forms one part, and the two bows another. But one base is necessary for any number of cases. The bows which here are separated from the base can be duplicated to any extent. They are held firmly by thumb-screws, and after a case is once articulated to the bows they can be laid aside for future use. The lateral motion forbids the use of a prop to keep the bows apart. At first sight it would seem that the lower bow is moving in the wrong direction. Its motions are precise and correct. This has never been changed in design since first invented, in 1858. It permits of seeing whether the palatal and lingual cusps properly touch. In using it to get the lateral movement, one condyle must be kept close to the point where it is held by the spiral spring, while the opposite one moves forward. Never use both springs at once, except in bringing the lower jaw forward for incising. This method demonstrates that there is but one way to make a set of teeth articulate.

"Before placing the wax models in the articulator, it will not be out of place to say a word about this arrangement of the wax on the base plate and the selection of teeth in full sets. Always model the upper wax first, judging of the length of incisors by the trial of an artificial tooth in the mouth, such as, in shape, length, and width, would look natural and appropriate when held under the lip. This will enable you to get the height of wax and the contour after successful trial. The modeling of the wax on the upper plate is not arbitrary or fixed, so far as a definite law is concerned, in being able to work after a set pattern; here the true dental artist comes in. You get the length by trial of several blocks, or single gum, or plain teeth, as may be, as well as shade of same. As to the arch of upper, you must add to and take from, making depressions, etc., until your judgment tells you it is correct. To aid amazingly in this work of art, draw out the patient in a smile or broad convulsive laugh; compel him to do so; nothing tends so to relax most universally every muscle and give true expression to the countenance. If the wax is not in keeping with symmetry you will see where the trouble lies. Look at them in front and on either side when they are laughing, as a sculptor would upon his model. Be sure that the arch at the cuspids that form a double keystone to the arch stand out more prominently than any others. The

superior first bicuspid should nearly always fall back somewhat behind the cuspids.

"Now that the upper wax is correct, the same rule applies to the lower. It is easy to make this conform to the upper; you may have to change the upper in some respects when tried with the lower, but not much. The length of wax at the molars may have to be trimmed to allow of equalizing the length of the teeth on upper and lower plates. Laughing and smiling will here again tell. Be sure to mark the center at the median line, making marks or grooves through on either side, running from upper to lower for guide; they can be removed and are now ready for the articulator, with their bows pushed into their sockets in the base, which are retained by mere friction. The plaster models or casts with the wax articulation or bite thereon—and all fastened together by wax or cement to prevent being displaced from the cast—are now placed on this lower bow of the articulator, and the upper bow brought over upon the upper cast. Your eye soon detects whether the median line or wax is in the center. To get the cast in proper place have a pair of calipers four inches between points, and by it place the cast in position, with center of lower teeth just four inches from the condyles on either side. Hold in position while with plaster you secure the upper to the bow, and when hard, the lower bow to the plaster cast in the same way.

"It may be asked, Where is the set screw to hold open the jaws of articulation after wax is taken off? I have never found it necessary in this kind of frame. Before taking off the wax, I take a pair of dividers, or a piece of wire bent with the points about one inch and a half apart, and mark, with one foot on plaster cast and the other at cutting edge of wax, the bite at the median line. Do this for both jaws. To secure this height for future repairs mark on each cast with the dividers the distance apart or width of dividers, and this will always be your guide for height. Take off all the upper wax—except a section at the molars—first, and let the lower remain as a guide for the arch of the upper. The first block or tooth fitted on the upper when backed with wax answers perfectly to keep the jaws of the articulator apart. The set screw would be in the way with the lateral movements. I stated that the length or depth of underbite in full sets is restricted to the width of the jaws and length of the centrals, which it is presumed have been selected to suit the individual case. Knowing how much the underbite is to be, you can very nearly guess how much to cut out the bicuspids and molars on all the grinding surfaces *before any of them are fastened to the base plate,* and how much arch upward at the ramus, from the second bicuspid backward and upward. If the underbite at the centrals is to be an eighth of an inch, then the bicuspids in the

upper will have grooves between the cusps not quite so deep, and the molars still less. From the cuspids, then, the cusps are less to the second molar; were the incisors to strike equally and directly upon each other there could be no cusps or they would be of no use. The inner cusps of the upper should, as a general rule, be longer or higher than the outer. (See Figs. 996 and 998.) The outer cusp is more acute, the inner rounded. The lower the reverse—inner sharper and outer rounded, where the upper closes over the lower. For full sets you need but slight underbite, only enough to permit the lower to come forward and act as shears for cutting; at the same time it permits of cusps to both bicuspids and molars, and gives all double amount of grinding surface, there being cusps that touch on palatal and lingual sides, at same time as the buccal. Always bear in mind that the curvature upward at the ramus, of the upper set, is always in proportion to the underbite.

"If for an upper set alone you can tell how much the upper incisors should overbite by looking at the curvature of lower molar teeth remaining. If an eighth of an inch out of line the overbite should be fully so. This, when once understood, can give no trouble. The grooves in bicuspids and molars will form with the cusps, buccal and lingual, an ogee, as seen in Figs. 996 and 998, to give double the grinding surface when worked laterally, besides giving double cutting edges. All these grooves can be cut out before any are fastened with wax, so nearly that but little touching will be needed when the lower is articulated to upper. *The first bicuspid in the lower jaw should have but one cusp.* This perfect design will be seen in the articulator why it should have but one. Two would not only be in the way of the tongue, but be of no use. Be sure that the groove in the upper is made nearer the buccal side, and for the lower or lingual side, for a reason which you will presently have explained, as seen in Fig. 996. Now that the grooves are completed in the upper and all the teeth in place in the arch, we will articulate the teeth on the lower base. The height is soon ascertained by the dividers, and the central incisors tried on to see what changes will be needed. Fasten it temporarily with wax, and try it with the lateral motion and the points adjusted to meet all the surface on palatal side of upper teeth, when the lower is thrown to the side of the tooth being fitted. Cut from the cutting surfaces of each, whichever will make the most natural and strongest case. If for a very young subject, be careful; but for a middle-aged or elderly person do not scruple about the cutting edge and grinding surfaces, but sacrifice even the labial or palatal surface for the sake of effect and usefulness.

"I sometimes turn the buccal side of a molar inward to save sub-

stance and get effect and for better adjustment ; frequently for want of room at ramus I do this; and, occasionally, turn buccal side upward for the grinding surface. If using blocks, before the front ones are fastened securely to the base plate, and while they are temporarily in their right place, try the bicuspid blocks to find out how much of the joint should come off of the incisors or the bicuspid block, or divide it. This will secure a better and more continuous joint and give the lower better chance to be arranged to the upper. Before

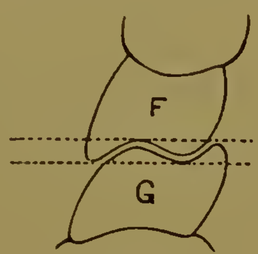

FIG. 996.

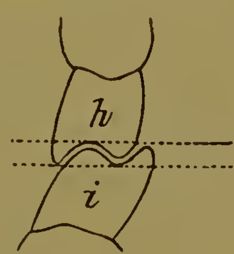

FIG. 997.

taking off too much of the joint of either of these blocks try the lower incisor and bicuspid block temporarily on wax, to know where the cusps are going to come. Regulate the joints by this. You can make the groove in the lower blocks the reverse of the upper, and cut them all out before much jointing is done, taking care that the groove is now on the lingual side and that the buccal cusps are rounded and the inner more acute, as in the buccal of the upper. *Never cut off any of the lingual cusps of the lower bicuspid and molar teeth,* such as are now made, as they are universally too short, and to

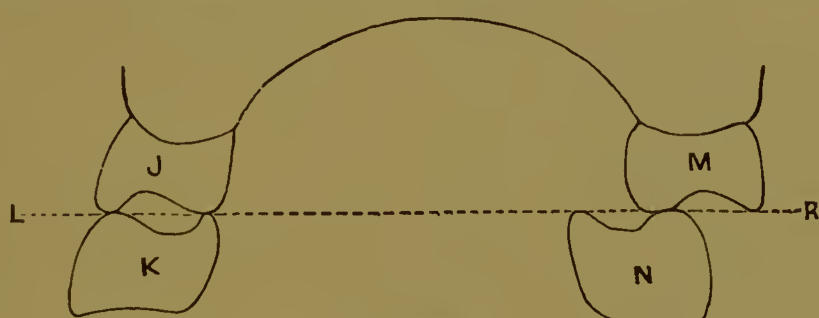

FIG. 998.

get them long enough for service a large portion of the buccal cusps have to be cut down and rounded.

"The palatal cusps of the upper strike between the outer and inner of the lower (see Fig. 996) and, at the same time, these cusps should be long enough to allow in the lateral movement the incisors and cuspid on that same side to touch simultaneously all the surface from the central to the last molar. If they do not, then your remedy is to make the groove deeper in both upper and lower, or perhaps the lower only, or the upper only (see J K, Fig. 998) ; experience here

will soon teach you which. When all the cusps are touching, inner and outer and the front one, take the opposite bicuspid and do likewise; and with the additional precaution, when the lower jaw of the articulator is turned to the left, to make the inner cusps of the upper strike the outer cusps of the lower (M N, Fig. 998) and *vice versa*, when thrown to the lateral right or left (J K, Fig. 998). The molars must have the same rule applied, with yet another additional point of great importance.

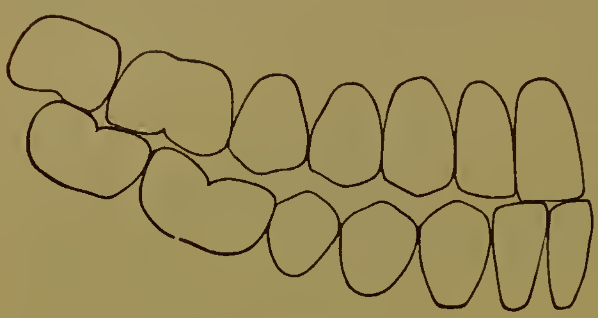

FIG. 999.

"The curvature of the ramus must be made to conform to the depth of overbite (see Figs. 999 and 1000), so that when the lower jaw is thrown to the right, the outer and inner cusps of both upper and lower sets on that side come together at the same time that the bicuspids and incisors do (see Fig. 1000); but the curvature should be great enough to permit on the opposite side of the second molar tooth in the lower, which slides forward to meet the first molar in the upper, apparently moving backward (Fig. 999)—if they were on a plane they would never touch, on account of the jaws opening as they move laterally to the right or left—to mount up on the cusps of the incisors an eighth of an inch, which would not allow the molars to touch, if on a straight line backward. But, inasmuch as on the plane of grinding surface the first upper molar stands higher in the upper plane, the sliding forward of the lower jaw in the glenoid cavity brings the higher second molar in the lower in continuous contact with the first superior molar, as well as both outer and inner cusps of bicuspids and molars of the upper and lower jaw (Fig. 999). This is specially done to equalize the pressure and force on both sides or parts of the dental arches. This permits of the most compensating arrangement of the teeth for equalizing the action of muscles on both sides simultaneously, and getting the greatest amount of grinding surface at each movement. This arrangement of bicuspids and molars is found in nearly all the lower animals; *the incisors, however, never touch when the jaws are in lateral movement*. Turn the lower jaw to

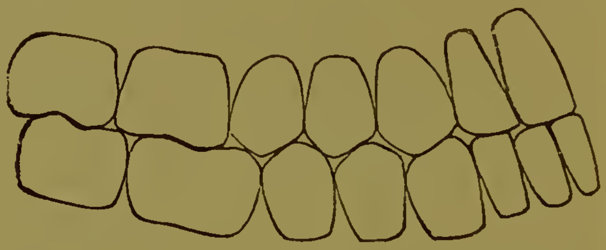

FIG. 1000.

either side and the effect is the same. *As I before said, but one side of the mouth can be used at the same instant, leaving the other free to balance the other side at work.*

"If the upper arch of incisors *of the natural teeth* should be broad or deep on account of the thickness of the base or body of the incisors, or where they are much inclined to protrude, then the arch at the ramus is not so great. In artificial sets this need never occur, carrying out the same rule in nearly every case, of controlling the curvature at the ramus by the depth of overbite and length of cusps of bicuspids. This system holds good in partial sets as well.

"This is all that is necessary to be said on articulation proper; it remains only to give a few points having a bearing on the perfection of the same. Select the broadest grinding surfaces to bicuspids and molars, that the bolus of food may be held securely on their faces, taxing less the muscles of the face engaged in mastication. Narrow surface would rather tend to cut the food than grind it. This is of no mean importance in rendering artificial teeth of greatest use.

"To produce the most natural effect the centrals should be the lightest in color, and the cuspids a shade or so darker, with a difference in color of all the back teeth. I prefer on this account to set plain teeth wherever admissible—and nearly all lower cases are so—and use different shades and arrange irregularly. The lower incisor teeth are mostly crowded, and I find to lap them over and distort them, even to a great extent, adds very greatly to their natural appearance. Don't be afraid of getting any case too irregular; very few natural sets can boast of perfect symmetry.

"After the teeth are fixed temporarily on the plate they should always be tried in the mouth to see if they are perfectly correct. As the mouth is more yielding in one part than another, the closing of the jaws rather firmly will allow of slight readjusting of themselves on the wax. If, when finished, they are found not to articulate properly—which is sometimes the case from the soldering or vulcanizing—have the patient bite on a strip of wax placed between the grinding surfaces to show the relation of each. Then put this back into the articulator and rearrange the grinding surface. It will be found to need but a trifling alteration.

"The false movement of the lower jaw at the condyles is found in nearly all persons who have had but one or two teeth remaining in the front arch, to reach which the jaw must be thrust forward and laterally; and when artificial ones are placed in, the same old movements are continued until their attention is called to it. It can be corrected without any special arrangement other than following the law herein laid down.

"*The Equilateral Triangle within the Main Triangle.*—The outline drawings in Fig. 1001 may be thought *ideal.* But any one at all acquainted with geometry, who has followed me in my argument and description, must be struck with wonder at the marvelous ingenuity of the contrivance based alone on the equilateral triangle. It will be seen that perfection must be the result, since each part is complete within itself and the whole supporting each individual part.

"How have I arrived at this divination? The law is based upon the measurement of over two thousand human skulls. First, make an equilateral triangle, 4 inches each angle, A, A, F; draw a line from T to F. What is the guide to form the arch? Know the actual width of the superior central, lateral, and cuspid at their greatest diameter from the mesial to distal surfaces, say $\frac{13}{16}$, as in Fig. 996. Measure this off with the dividers, and place one arm at F and describe an arc from D to D through I. Then place dividers at I, and intersect the line just made from F, and it will be found that at D will be found the extremest point of the arch D, F, D, and will be the distal surface of the superior cuspid. Place the dividers at I, and describe the arc from D to D through F, which will constitute the normal and positive arch of the superior jaw. There will be an equilateral triangle from D, F, I on either side of the mesial line at F. The same will be found the base of each superior incisor.

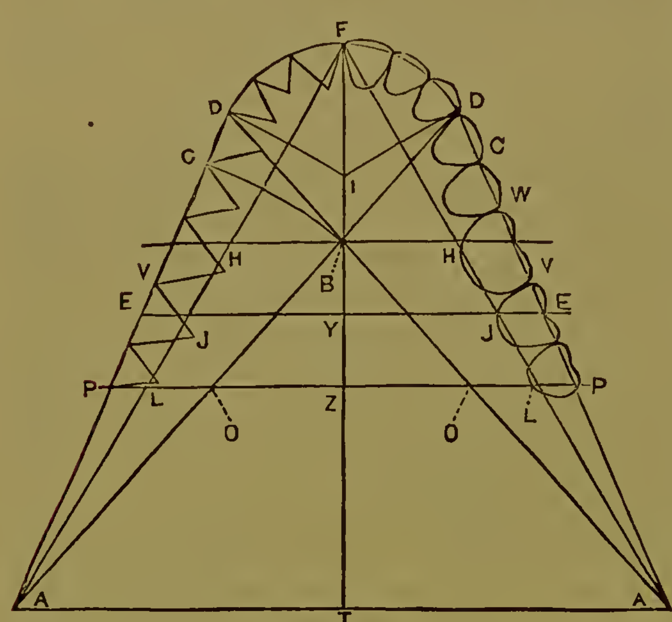

FIG. 1001.

"Next draw a line from A to D on either side, which will be the guide for the bicuspids and molars as to width and depth. Then, by placing the dividers at A and B, describe another arc to C, which will give the width of first superior bicuspid. The line from A to D passes through its palatal base, and will pass through center of base of triangle of this tooth. Form another triangle by drawing a line from H to H, through B, which will pass through the center of the first molar, and will give the width between the palatal surfaces, or their depth or thickness. Placing the dividers at I and F, we intersect the

line from F to T at Y. Draw a line through Y to E, E, forming another equilateral triangle. From B to F is now the radius of another arc, which intersects the line from D to A at V, and the line A to D at O. A line now drawn E to E through Y intersects the center of the second molar at E, E.

"Get half the distance between the points at E on the line from D to A, and the width of the first molar is made, and also the second, which is the angle of the equilateral of each. This leaves room between the first bicuspid and first molar, and is the width of second bicuspid; or it is shown by placing the dividers at A and Y, and intersecting line from D to A at W, same as from B to C, for the first bicuspid's width. The distance from D to D is the same as from D to the distal surface of the second molar. P to P through Z forms another equilateral triangle, giving the wisdom tooth's place in the arch.

"The arrangement of J and K (Fig. 1000) on the left shows the teeth in the act of mastication, while on the right M and N (Fig. 999) the inner cusp of molars of the upper and outer of the lower molars come in contact when not in use. There is double the surface touching at every lateral movement. Fig. 999 shows right side, as at M and N, and Fig. 1000 that of left side (J, K) in action from the mesial to the last molar. Fig. 996 shows both bicuspids and molars in normal relation."

Dr. W. Storer How* has described a method of utilizing plaster impressions for obtaining accurate antagonizing models as follows:—

"In the process of procuring counterparts of the jaws for which dental substitutes are to be constructed, every step should be taken with the greatest degree of exactness attainable, and accurate impressions are therefore essential as matrices in which the working models are to be cast. Impressions of edentulous jaws are commonly taken in mixed plaster, which is held in the bare tray, or in the wax impression previously taken in the tray. An elucidation of this part of the subject is not now entered upon, but it is assumed that in any case, whether the jaw be completely or partially toothless, an impression will be taken in plaster, and that, when practicable, the thinnest part of the body of the impression will be not less than the sixteenth of an inch thick. Fig. 1002 exemplifies such an impression of a toothless upper jaw, and Fig. 1003 in like manner illustrates the plaster impression of an edentulous lower jaw. In both instances the trays are omitted from the cuts as not necessary to be shown.

"Plaster impressions are commonly varnished with an alcoholic

* *Dental Cosmos*, September No., 1888.

solution of shellac or sandarach, and then oiled to insure the separation of the casts. The preferable way in most cases is to thoroughly brush the surface with a soft brush and strong soap-suds, and, after an interval of a few minutes to allow for absorption of the water of the suds, to fill the impression with a properly mixed batter of plaster.

"Several hours should preferably elapse before attempting to separate the cast from the impression, which should be preserved as nearly entire as possible, and when there is not much overhang the separation may be safely effected by progressive smart tappings with a light mallet over the whole surface of the impression. If, however, the labial portion must needs be first cracked off, this may be done, after cutting a groove in the impression as near along the crest line of the cast as may be guessed, using quick, light mallet-blows to knock off the sections. These are to be carefully kept, and after the separation has been accomplished are to be replaced with the palatal portion on the cast and with a thin-mixed plaster built up to the approximate shape

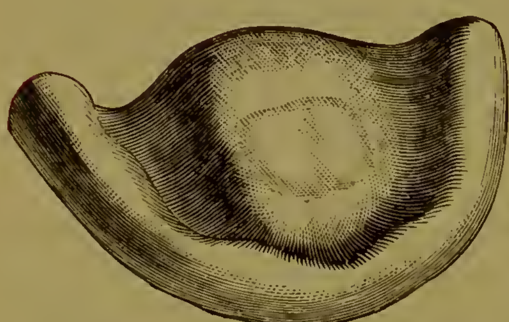

FIG. 1002.

FIG. 1003.

of an articulating model. When this has become quite hard it is removed from the cast, which, of course, it perfectly fits. It will also, if as an impression it was correctly taken, perfectly fit the jaw, and may therefore be placed in the mouth and judiciously trimmed until the proper expression has been produced, and the exact dimensions and contour of the desired denture embodied in this plaster articulating model. Such a model is shown in Fig. 1004. In like manner one may prepare a similar model of the inferior jaw. Such rigid and exact-fitting models can obviously be replaced, trimmed, and readjusted in the mouth until the best skill of the dentist shall have been expended in obtaining models at once artistic and correct. The median-line mark is then made with a pencil or knife, and cross-lines are made on the sides of both models while they are pressed together in the mouth, after many openings and shuttings of the jaws, to be sure that at last the proper relations of the models have been obtained. The occluding

surfaces are then dried, warmed, some hot wax is dropped on them, the models are instantly replaced in the mouth, and the side-marks and median-line marks made to exactly coincide, while the models are pressed together by a firm closure of the jaws until the wax has quite stiffened. The joined models can then be taken from the mouth and replaced upon the casts. These are to be fixed with care in a suitable articulator, and the result will be a precise reproduction of the relative positions previously occupied by the models when placed on the natural jaws (see Fig. 1005). Attention is here called to the fact that, normally, the horizontal line of occlusion is not straight, but curved so that the superior cuspids are at the bottom of the depression, as illustrated in the lines of the models, Fig. 1005. In the construction of models for full dentures it is important to maintain this curved line of occlusion for two reasons: First, the process of mastication is facilitated by the impingement of the lower bicuspids and molars, as these

Fig. 1004.

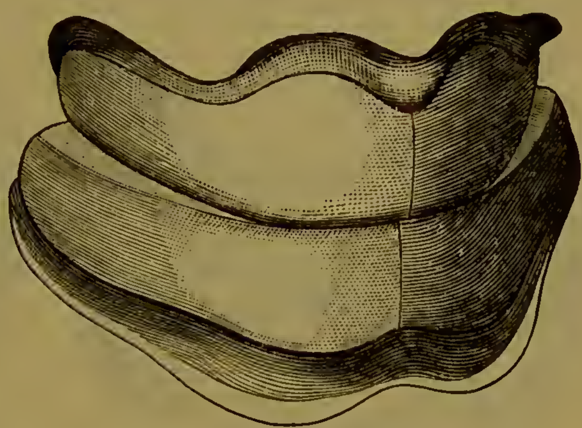

Fig. 1005.

are occluded with their downward-graded antagonists by the antero-lateral movements of the lower jaw in the act of grinding the food; second, the facial expression is improved by the rising of the respective planes of occlusion at those points, thus in some degree producing the effect that the limner accomplishes by upwardly-curved lines at the corners of the mouth.

"Fig. 1006 also shows (though imperfectly) the correctness with which the plaster models may be made to anticipate the outlines of forms which the completed dentures are subsequently to assume in becoming both useful and beautifying works of art. The thin, sharp, inflexible borders of contact with the gum along lines which provide for a firm bearing of the model, and yet permit the free play of all the muscles concerned in acts of mastication and facial expression, are noticeable in Figs. 1004 and 1005 as being producible in plaster models. It is likewise observable in Fig. 1005 that the normal overlap of the upper incisors upon the lower may be reproduced in

plaster models and prove an important factor in sustaining the lips in proper profile relations,—a circumstance too often ignored or overlooked in the preparation of the ordinary wax models. These are, in fact, commonly so crudely and clumsily formed, and are withal so lacking in resistance to adverse impressions, that not only can no dependence be placed upon them as correct representatives of the relative parts previously studied and produced in the mouth, but from the very fact that wax forms are so easy of displacement and disfigurement, the steps in the process of obtaining such articulating models are hesitatingly and hastily taken, and of course result in faulty dentures, which, more than any other class of dental operations, proclaim the frequent failure of the dentist to so closely imitate nature as to conceal the fact that such an endeavor has been made. The practical permanence of the plaster model obviates all these defects, and, furthermore, admits of such a firm final closure of the jaws

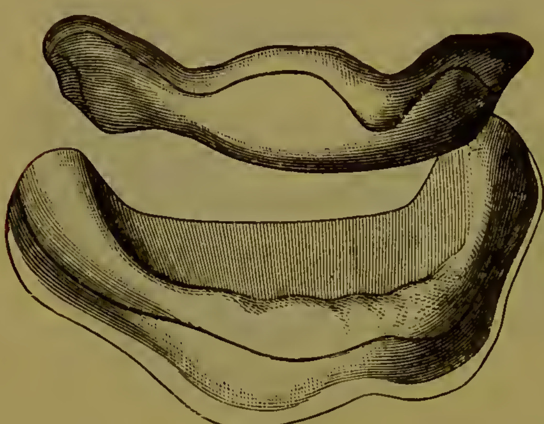

FIG. 1006.

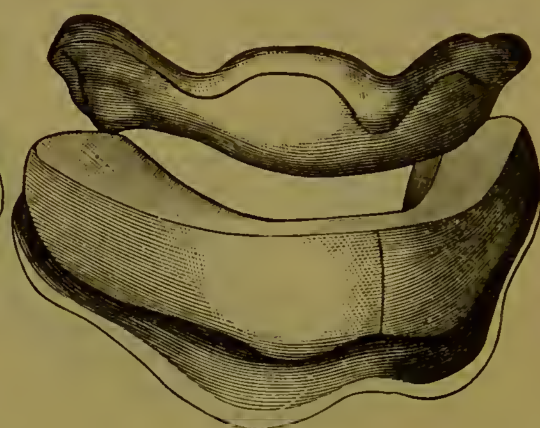

FIG. 1007.

that, when at last the corresponding denture is placed in the mouth, both the occlusion and the articulation are found to be correct, as could never be the case after a timid trial closure upon a soft, slippery wax model.

"In Fig. 1005, as in the succeeding figures, the models and casts are to be viewed as mounted on articulating frames, which do not appear because not necessary for the purpose of illustration.

"Upon the removal of the models from the casts, after these have been mounted on the articulator, both representatives of the edentulous jaws will appear as seen in Fig. 1006, and in these cases the border outlines of the models are indicated to emphasize the need of making them conform to the muscle insertion lines whenever this is practicable; and that not only because of the increased stability of the dentures when they are free from liability to displacement by the lifting action of muscles improperly so covered, but also because

the mobility of the adjacent features in the consequent naturalness of the facial expression will depend in great degree upon the judicious definition of the boundaries of the dentures.

"Fig. 1007 shows the cast of the upper jaw in its relation to the articulating model in place on the cast of the lower jaw, and Fig. 1008 likewise illustrates the cast of the lower jaw as related to the articulating model in position on the cast of the upper jaw.

"A close observation and study of these illustrations will make clear the many points of advantage to be obtained by the employment of plaster in the construction, fashioning, and adjustment of prosthetic models for full dentures.

"Complete upper artificial dentures for use with more or less complete lower natural dentures constitute a large class of the cases coming within the province of the dentist, and for these the plaster articulating models are especially adapted.

"Such a model as that shown in Fig. 1004 may be suitably shaped

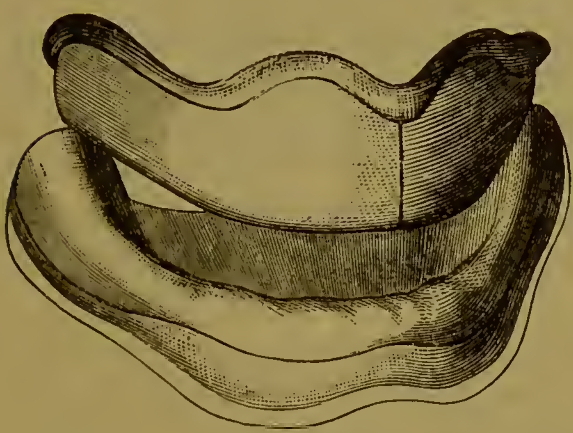

FIG. 1008.

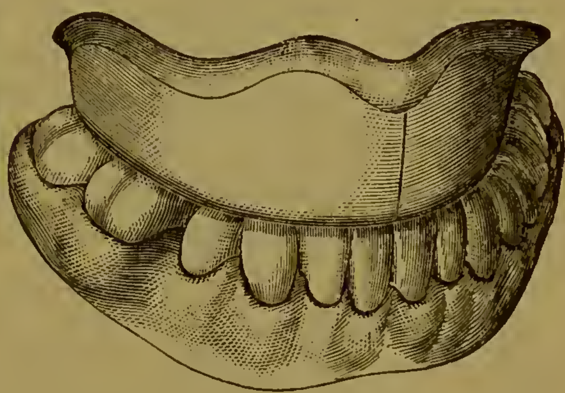

FIG. 1009.

to articulate with the natural teeth of a lower jaw, as illustrated in Fig. 1009, and in the process of shaping the plaster model great satisfaction will be derived from the security of the model's retention in the mouth, the firmness with which the lower teeth may be closed upon it, and the certainty with which, by frequent repetitions, a natural occlusion may be obtained. When this has been done, and all the artistic conditions are complied with in perfecting the shape of the model, it is to be removed, warmed, and thus dried on its occluding surface, so that a roll of very soft impression-wax may be placed upon it and all be quickly replaced in the mouth.

"Repeated normal closures of the jaws are to be made, and the jaws are then held tightly closed while the fingers of the operator are rapidly pressed upon the wax which covers the face of the teeth, so that on opening the jaws and carefully removing the model and wax there will be found an accurate impression of the teeth, which

will have to pass through the wax to the model, pressing it firmly into its seat. The result is shown in the articulated model and cast. Fig. 1010 shows the articulated casts when the model has been removed.

"If proper care has been taken in pursuing this process up to this point, the succeeding steps in the construction of a continuous gum, gold, celluloid, or vulcanite denture may be taken with complete confidence that the substitute, if made in strict conformity to the models, will exactly fit the maxilla, articulate with the natural teeth, and impart an appropriate expression to the related features of the patient.

Fig. 1010.

"The foregoing method may in some cases be practiced when modeling composition has been used in taking the impression; or the composition may be employed in building the model upon the cast which has been made from a plaster impression. But for general use—and all the more so as the practice shall become familiar—plaster will be found most reliable and satisfactory as a material for both the impressions and the models."

CHAPTER XI.

SELECTION AND ADJUSTMENT OF PORCELAIN TEETH TO THE PLATE—FINISHING TOUCHES.

In selecting porcelain teeth for dentures a number of points must be considered, such as *Size,*—width and length, especially of the front teeth; *Shape,*—straight or wedge-shaped; *Shade,*—to conform to age and temperament, and for partial dentures to match natural teeth in the mouth; *Character,*—flat, or curved on the labial surfaces, transversely or from the gum to the cutting edge, thin, translucent, and delicate, or thick, dense, and massive; *Peculiarities,*—the presence or absence of grooves, ridges, or lines, straight or rounded cutting edges.

Where vacancies between natural teeth are to be filled it is highly important that the artificial teeth should correspond in shade and

color with the natural organs; for in proportion as they are whiter or darker, will the contrast be striking and their artificial character apparent. Of the two faults it is better that they should be a little darker than any whiter. They should also resemble in shape those which have been lost, so far as it is possible to ascertain this. Minute accuracy as to shades of color involves the necessity of a large assortment, unless one is located near a depot or agency. But the facilities of mail and express greatly lessen this necessity, provided there is time to send for the tooth or teeth required. It is desirable, in view of this method of matching shades of color, to keep all refuse or broken teeth to be used as samples in sending orders.

The manufacturer supplies three varieties of plate teeth—plain, gum, and sections. The latter have the advantage of showing few joints, but are less easily repaired and are not applicable to so wide a range of cases. Gum teeth or sections are applicable only where there has been sufficient absorption to permit the extra fullness of the artificial gum. Many mouths are deformed by a foolish craving on the part of the patient, which the dentist is equally foolish in yielding to whenever plain teeth are more appropriate. In point of strength, durability, and facility of repair, plain teeth are superior to the others; they are also more readily adapted to the plate.

The manufacture of gum teeth in sections of two, three, or four teeth has been brought to such perfection that comparatively few single gum teeth are now used; especially since new methods of attaching these sections to the plate have rendered unnecessary that exact fitting of blocks which was one objection to their use. This perfection of manufacture has also done away with the necessity, on the part of the dentist, of devoting to the making of block teeth the very large proportion of his time formerly demanded by this difficult process. Whenever special cases demand blocks or sections made to order, it will be found more satisfactory to send proper models and descriptions, and have such teeth made by those who are thus constantly occupied, than to incur the disappointments and delays inevitably attendant upon infrequent and irregular attempts at block-work.

For the proper shaping of models and articulators to accompany such orders directions will hereafter be given. These blocks, when received, do not need much, if any, grinding. But all plain teeth, single gum teeth, and ordinary sections or block teeth require, after selection, to be more or less accurately fitted to the base plate. For this purpose they must be ground on emery or corundum wheels until accurately fitted, and must be so arranged, in full cases, as to meet the teeth with which they are intended to antagonize at the same

instant around the entire arch; in partial cases the natural teeth should touch their antagonists more decidedly than the artificial ones. A correct articulation will enable the dentist to antagonize the teeth with perfect accuracy.

The movements of the tongue, lips, and cheeks must be considered in the adjustment of artificial teeth, and the expression must be carefully studied; hence some general rules may prove serviceable. The median line of the face should exactly come between the upper and lower central incisors; the centrals and laterals on each side should lean slightly toward the median line, the laterals a little more so in most cases than the centrals, the cuspids very slightly, and the bicuspids and molars almost perpendicular. In a full denture the anterior teeth should lap but slightly, only enough to permit the cutting edges of the upper front teeth to pass over those of the lower teeth; the six anterior teeth, therefore, should not meet, but the pressure should be upon the bicuspids and molars, and be equal on both sides. Lisping is prevented by having the front teeth lap but slightly, and the stability of the denture is increased. The articulating model will govern the length of the teeth, especially the anterior ones. The arrangement of the posterior teeth should correspond to that of nature, the articulating surfaces of the inferior second bicuspids and first molars curving downward, so that the second bicuspids and first molars are somewhat shorter than the first bicuspids and second molars; by such an arrangement the denture is less liable to be forced forward in mastication.

For proper expression the anterior lower teeth should occupy a perpendicular position, as it is seldom necessary to incline them outward or inward. Even when the lower jaw projects somewhat the lower teeth should be perpendicular and the upper teeth incline or project out to meet them. Fullness of the gum under the nose should be avoided, as the lip is given an unnatural fullness by such a thickness of material. It is frequently necessary to make considerable fullness of the gums of the cuspid teeth.

There should be an outward curve of both upper and lower teeth when the face is observed in profile.

In arranging an entire set for the upper or for both jaws the molars should be so adjusted that the inner or palatine tubercles come together as well as the outer ones. This precaution is necessary in antagonizing single as well as block teeth. If the outer tubercles strike first the pressure there will spring and loosen the plate. For the same reason upper molars and bicuspids should not be set so that the force of mastication falls outside of the ridge. The inferior teeth should be placed well on the alveolar ridge, and not inclined

inward or too much outward, and sufficient space be allowed for the movements of the tongue.

The lower teeth of an entire denture may with advantage be longer than the upper teeth, and thus insure greater stability; hence the lower front teeth (incisors) should be arranged first, then the upper teeth of the same class, and the same rule followed in regard to the remaining teeth. An unnatural regularity in the arrangement of artificial teeth should be avoided, as a slight irregularity will often harmonize with the features. The first bicuspids of the upper jaw should articulate between the first and second bicuspids of the lower jaw, so that each tooth meets two opposing teeth. The upper first bicuspids should be partially hidden by the cuspids when the denture is in the mouth, and the upper bicuspids and molars should project slightly over the corresponding teeth in the lower jaw.

Placing artificial teeth outside the ridge is often a cause of failure in securing serviceable dentures. The curve of the arch in both jaws should be made by the six anterior teeth, and by these alone. The prominence of the cusps of the posterior teeth should be preserved; hence the necessity for careful articulation, that it may not be necessary, after the denture is completed, to grind off the masticating surfaces of such teeth. The greatest pressure of mastication should be upon the second bicuspids and first molars; hence the second molars may be arranged so that they are somewhat shorter than the teeth referred to.

In partial upper dentures supplying the first and second molars, and in some cases also the bicuspids, on both sides, should a natural inferior molar remaining in the mouth have an inclination forward, as is generally the case when the teeth in front of it are wanting, such a tooth should be avoided in the articulation; otherwise, the denture is liable to be forced forward by the pressure of such a natural tooth against the teeth on the denture, as such pressure increases as the jaws are closed together.

A small space should be left between the last tooth of the upper and of the lower jaw in those cases where the crown of the lower molar looks forward, its posterior edge being a little higher than the anterior.

It is often necessary to cut away a considerable portion of a tooth in order to make it fit accurately to the plate. This makes the process of grinding very tedious, unless the operator has a number of sharp-cutting wheels varying from half an inch to three or four inches in diameter. Corundum wheels of various shapes and sizes are employed for grinding teeth; also wheels of carborundum, a new material composed of carbon and silicon, the combination being effected by

electrical action; it is claimed that carborundum wheels and points cut faster than corundum, and may be used wet or dry.

Fig. 1011 represents an excellent form of corundum wheel (the suggestion of Dr. S. Lee) for jointing porcelain gum teeth, and is made of various grits.

These wheels may be attached to a hand lathe, such as represented by Fig. 1012 (Coy's noiseless hand lathe). The foot lathe is, however, far more convenient for laboratory use, where much grinding is to be done. Of these the depots furnish some excellent varieties. Fig. 1013 and 1014 represent the Snowden & Cowman and the S. S.

FIG. 1011.

White, which are admirable lathes for dental purposes, while in Fig. 1015 we have the Amateur lathe, which is a larger, stronger, and more powerful lathe, capable of very rapid motion; also adapted to the making of small instruments, handles, etc.

The lathe of Dr. Lawrence, with detached driving wheel and head that can be attached to any convenient board, shelf, or table (Fig. 1016), has advantages that will make it very desirable to many.

Wheels may either be set at intervals on a long spindle, or screwed singly on the end of the mandrel (Fig. 1016). In the latter case they should be fixed with a screw chuck in the center, so as to be quickly changed from coarse to fine or from large to small. In grinding the

wheel should revolve toward the operator and be kept constantly wet with a sponge held either in a sponge-holder or between the ring finger and little finger of the left hand.

The thumb and forefinger of each hand must be free to hold the

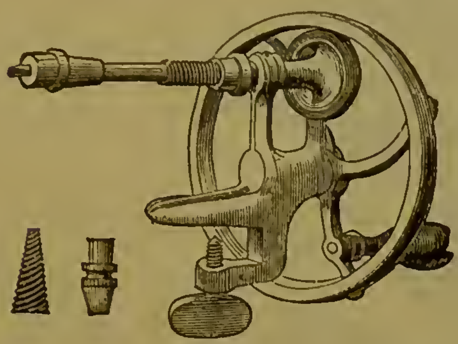

FIG. 1012.

FIG. 1013.

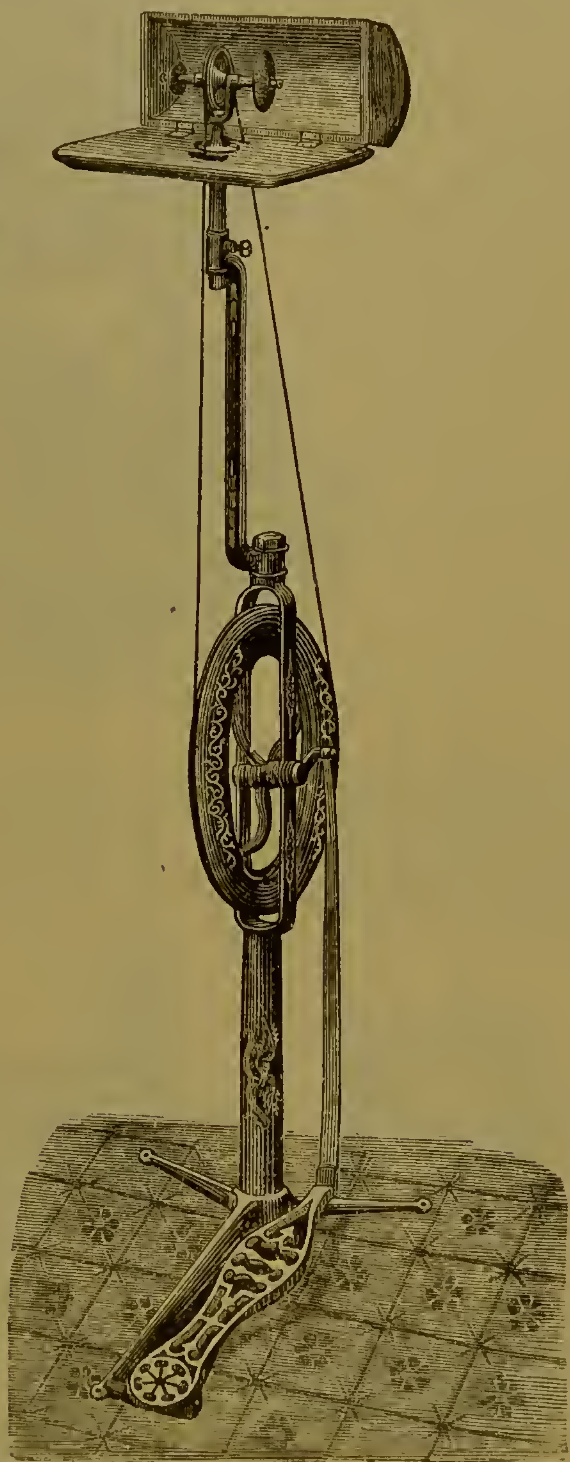

FIG. 1014.

tooth, the right wrist being steadily supported on the hand rest (Fig. 1017). Two faults are very common in grinding; one is revolving the wheel too rapidly; the other, bearing the tooth too heavily against the wheel. The first hinders rather than helps grinding; the second

is very apt to throw the tooth from the fingers and destroy the delicacy of touch necessary for accurate grinding.

Fig. 1018 represents the Coolidge grinding lathe head, which is also operated by a driving wheel, and can be attached to a table, and is an admirable appliance.

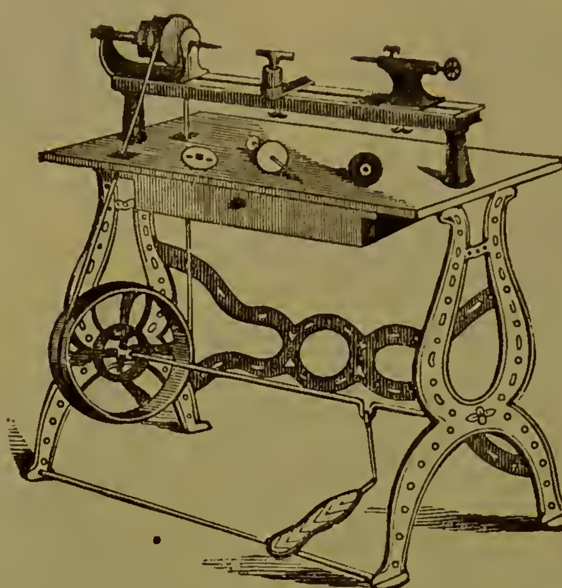

FIG. 1015.

In grinding blocks and gum teeth, and often in plain teeth, very small wheels are required to make them fit the curves of the plate. Thin edges of gum teeth and blocks must be ground with very fine-grained wheels; in jointing them a three-inch wheel should be used,

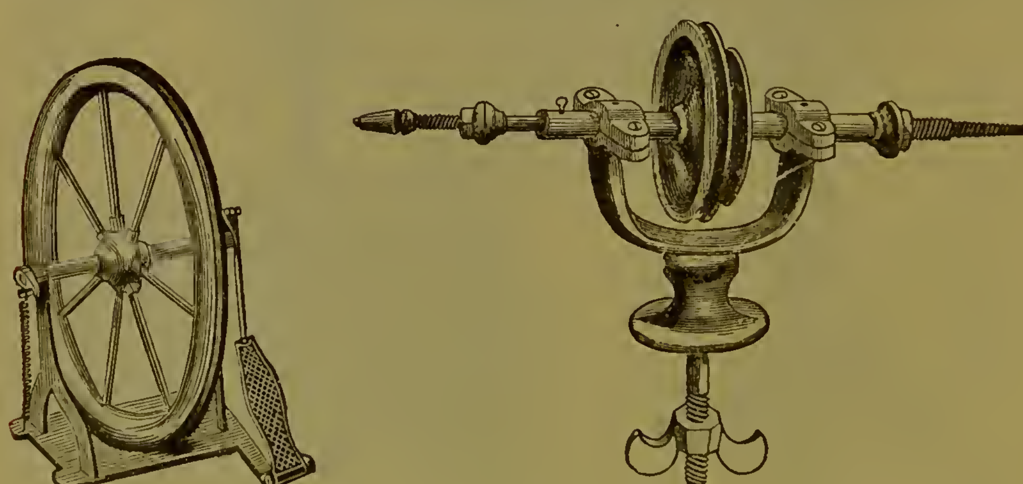

FIG. 1016.

perfectly flat on its outer side, and running very true (Fig. 1011). Wheels when worn down to small size increase in value, because they grind out curves inaccessible to larger ones. In warm weather large and thin wheels, when not in use, should rest on a flat surface; such

wheels are often warped by the softening of the shellac as they lie carelessly among other wheels. Wheels running on the end of a mandrel and attached by a screw chuck can be made to run true by warm-

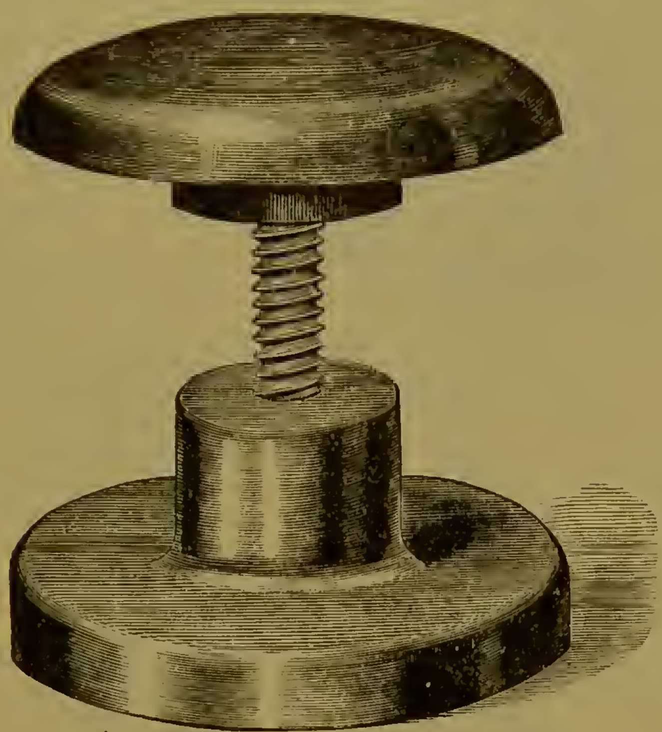

FIG. 1017.

ing the mandrel with a spirit lamp, and at the same time revolving the wheel rapidly.

The accuracy of the fit necessarily depends upon the kind of work

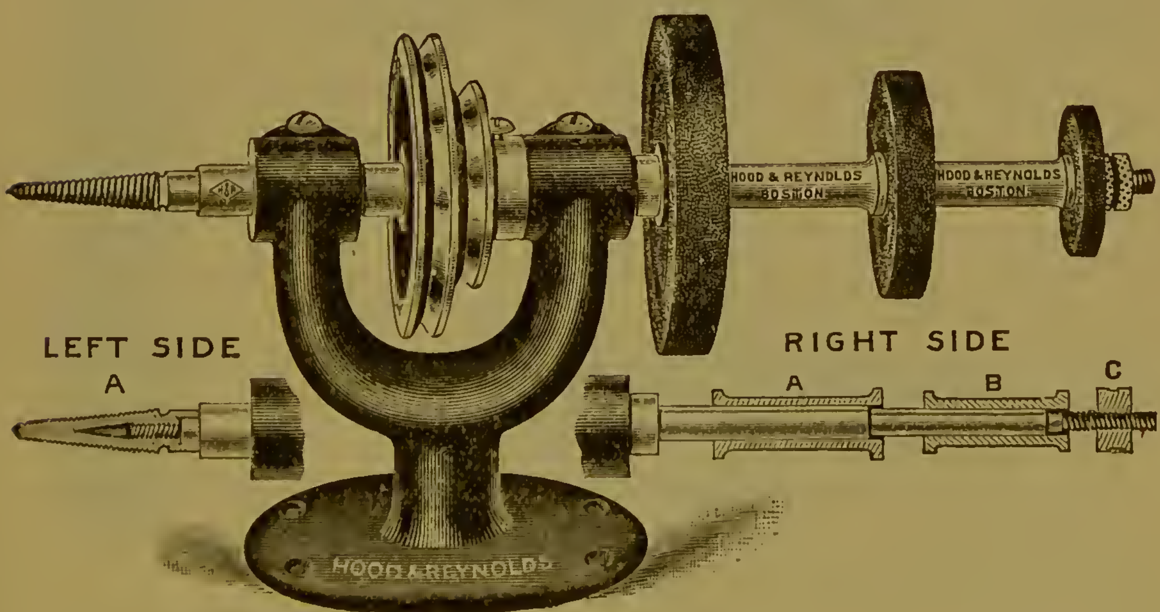

FIG 1018.

and mode of attachment to the base plate. In general terms it may be stated that whenever any permanent plastic material is in contact

with the base of the teeth, or forms the bond of union between the teeth and plate, grinding is much simplified. It is sometimes better in such cases to have a moderate space between the base of the tooth and the plate or the model, than to have actual contact. But in all cases the lateral jointing of block or single gum teeth requires care.

The order of grinding a set of teeth is usually to fit the central incisors, then the laterals, next the bicuspids, and so on; in case of sections, in the same order. This order will be found most conducive to uniformity of arrangement; of course, it may be modified to any desired extent. In case of a double set there is much diversity of practice. Some adapt, first, the entire upper set, others the entire lower; some, again, adjust the two sets of incisors, then the bicuspid blocks of both pieces, lastly, the molars. Whichever method is adopted, when all or part of one of the articulating rims is removed, the antagonizing rim must be retained to guide in the adjustment of the teeth.

Fig. 1019 represents a holder for teeth while grinding; a slot admits the pins, and the side clamp holds the tooth securely.

During the process of grinding the teeth are temporarily attached to the plate in several ways. Either the articulating rim is cut away sufficiently to receive the tooth (Fig. 1020), or the rim is entirely removed and its place supplied with a mass of wax covering the plate to the top of the ridge, and to which the teeth are severally attached as they are ground; others fasten the teeth to the plate with cement. Dr. Richardson gives the following formula for a tenacious wax for temporarily securing the teeth: Beeswax, ℔. j; gum mastich, ℥ij; Spanish whiting, ℥j.

For melting wax and its compounds in temporarily attaching teeth to metal plates and for "waxing up" the plastic work, the small Bunsen burners represented in Figs. 1021 and 1022 will be found very useful.

Fig. 1023 represents what is known as the "Duplex burner," which is well adapted for laboratory use. To the usual Bunsen burner is added a large flame for the blowpipe, which is applied by rotating the upper portion upon the base. By means of a small jet either flame can be ignited, rendering it always ready for use.

An excellent "waxing burner" is shown by Fig. 1024. The tube cannot be clogged with wax, as the heat will melt it and it will escape at the opening for the air-supply.

Definite rules of arrangement, or wood-cuts illustrating various forms of teeth and manner of setting them in the arch, are not all that is necessary. This branch of dental esthetics must, of necessity, be worked out by every one for himself. He will succeed or fail just in

proportion as he has the ability to observe the hundreds of models which are perpetually before him, and as he has the further and rarer ability to apply his observations to the special cases that are in his laboratory.

Imitation of nature is the rule. Imitations of art and individual

FIG. 1019.

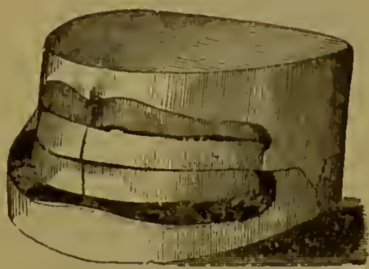

FIG. 1020.

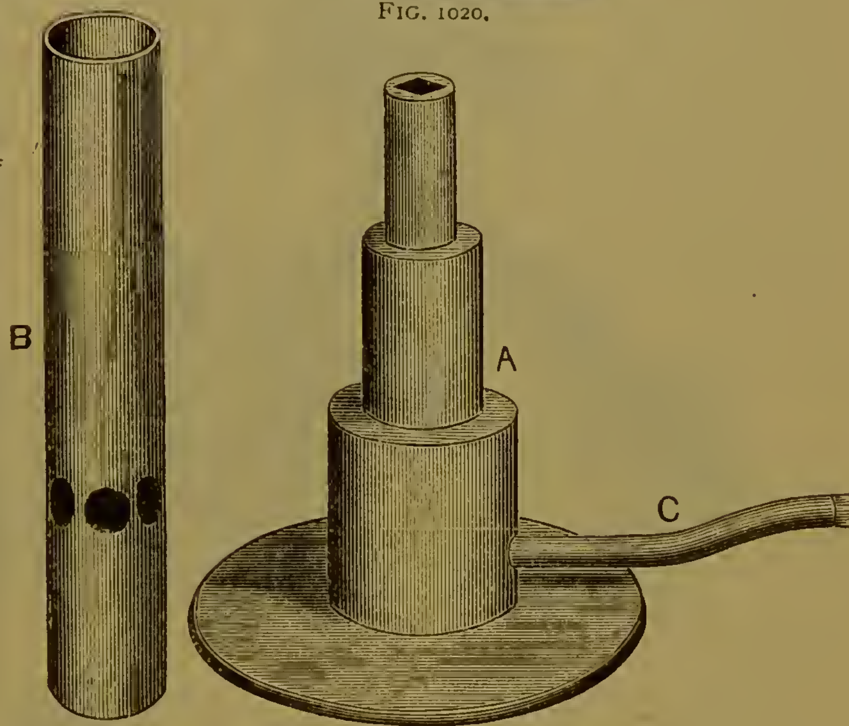

FIG. 1021.

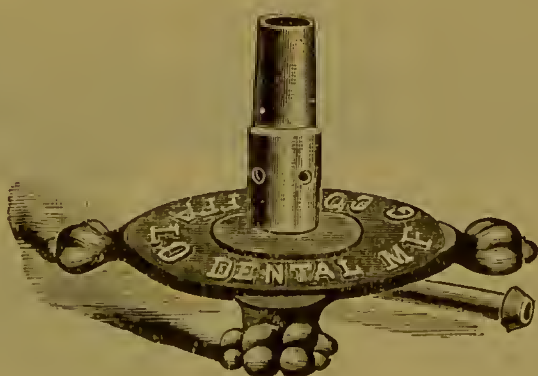

FIG. 1022.

incapacity make exact observance of this rule comparatively rare. We replace the sixteen teeth with only fourteen, and often make them shorter and every way smaller than the natural organs. We do not make the grinding surfaces interlock with such deep cusps as in nature.

At one time we cannot avoid an unnatural fullness of artificial gum; at other times the contraction of the absorbed arch compels the setting of molar teeth nearer the median line than the original teeth.

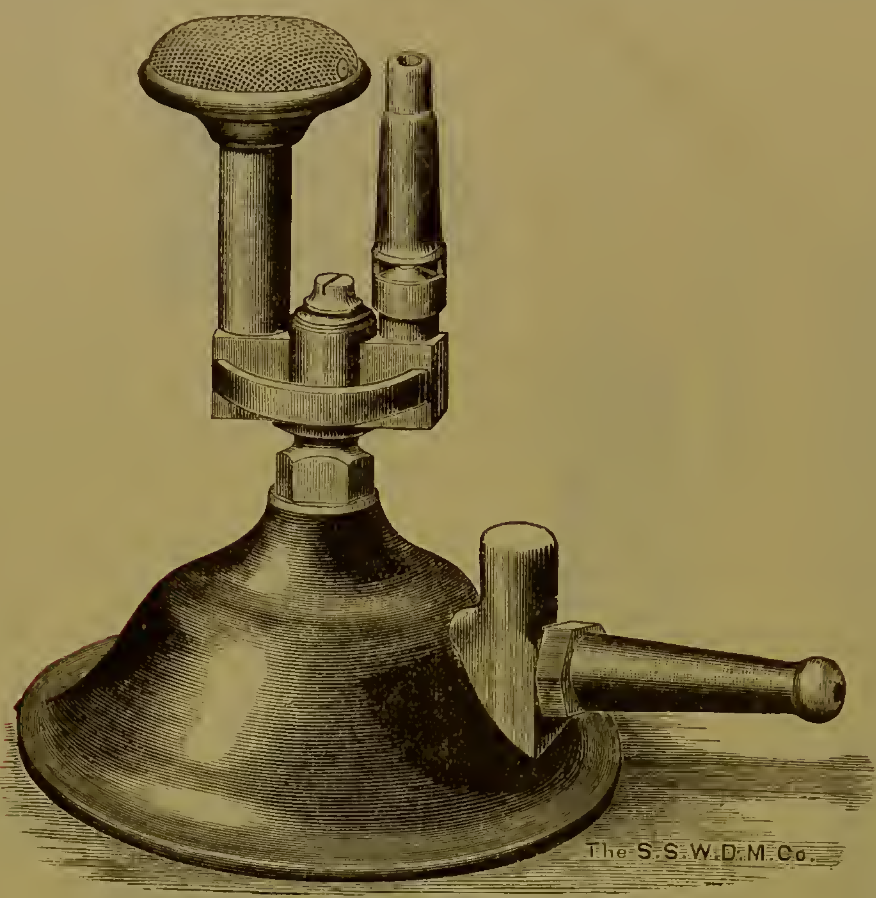

FIG. 1023.

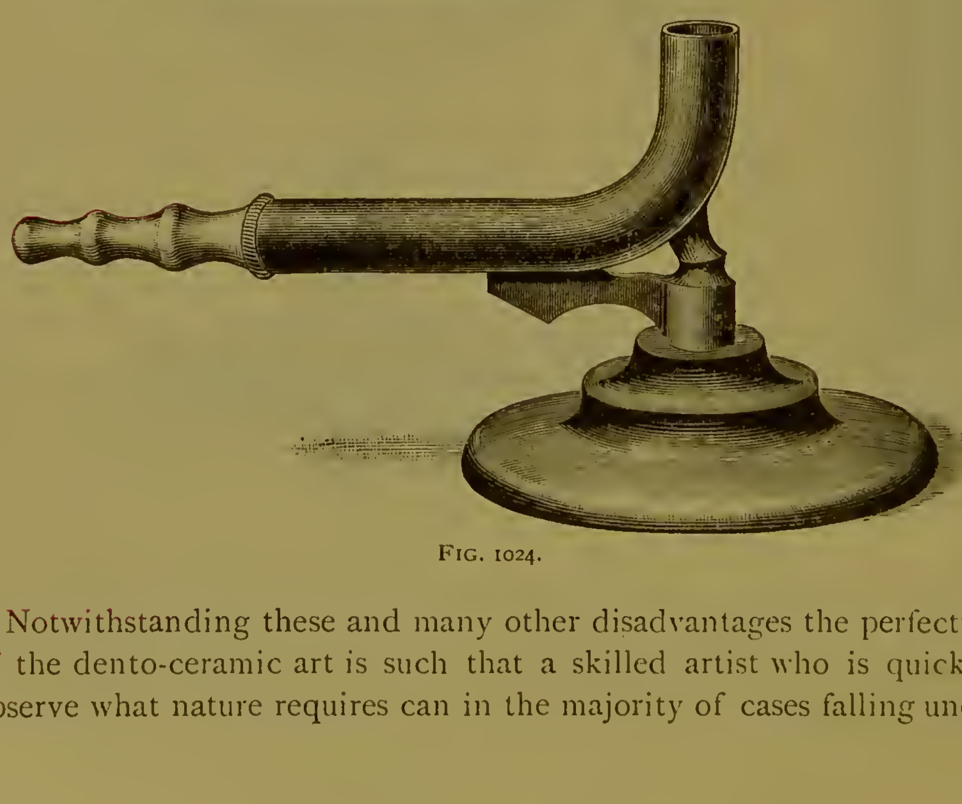

FIG. 1024.

Notwithstanding these and many other disadvantages the perfection of the dento-ceramic art is such that a skilled artist who is quick to observe what nature requires can in the majority of cases falling under

his care supply the lost dental organs with great accuracy, and preserve that higher order of beauty which grows out of the harmony of his work with the expression of the face and entire person. But no dentist can give to his work this kind of beauty who does not systematically study the natural organs as they daily present themselves in the operating chair. Few patients would object to the pressure of a roll of wax (two inches long and about half an inch thick) against the closed teeth. A model from this impression would give the size, form, arrangement, and articulation of all except the molar teeth. A well-matched porcelain tooth (more than one might be required) would add to these data the color of teeth and gum. To this add also the age, sex, physical characteristics of the face, and the physical temperament. If the dentist would have a case-book for the registration of one such carefully made observation every week he would, at the end of two years, have a collection which as a practical guide in the selection and arrangement of artificial teeth would prove of incalculable value. These fixed records of minute details are made still more useful by a habit of close observation in society. In this way a set style, or mannerism, may be avoided, which so often stamps work with meaningless uniformity of expression.

Artificial teeth should imitate the natural organs; yet there is a perfection of form and arrangement which it is not advisable to imitate. To disarm suspicion as to their artificial character, it is often desirable to impart a measure of irregularity. An overlapping lateral, a missing bicuspid, a worn canine, an incisor, bicuspid, or molar apparently decayed and filled with gold, an exposed neck from absorption of the alveolus, are among the legitimate devices of the skillful mechanician who has the "art to conceal his art." If there are any defective natural teeth remaining to be matched, still higher art is required. A perfect porcelain incisor is no fit companion for one that is partly broken, decayed, and discolored; and since no art can make the defective tooth perfect, and yet the patient retains it, there is no alternative but to give so much imperfection to the artificial one as shall take away that striking contrast which so painfully offends our esthetic sense of fitness.

In this class of operations a "diamond drill" is of great value; in fact, so very useful is it in many ways that we regard it as an absolutely indispensable instrument in the laboratory. Cutting away parts of teeth or blocks inaccessible to wheels; changing the shape of teeth near the gum; drilling cavities to be filled with gold, or holes for the repair of broken blocks, these are some of the operations which the diamond drill will accomplish as no other instrument can.

The selection and grinding of artificial teeth require, first, a high

order of esthetic culture; secondly, great patience and skillful manipulation. The latter are often taxed to the utmost to make a set of blocks answer the requirements of a given case; especially when the blocks must be closely fitted to a gold plate preparatory to attachment by soldering. Single gum teeth are more easily fitted to the plate; but there are some joints; hence it is doubtful if much time is saved. The principal advantage of single gum teeth is that a single tooth, if broken, may be replaced without interfering with the adjoining ones. Another reason why many prefer them is that a small stock of teeth in this form is adapted to a larger variety of cases than blocks would be.

We think, however, that dentists living at a distance from the manufacturer should depend upon a great variety of samples rather than upon duplicates of certain forms, however desirable.

In joining a set of blocks or single gum teeth one point must be remembered which has already been alluded to. In soldering the metal expands, while the teeth held in the investment are brought closer together by its contraction, and in this slightly altered position they are soldered to the plate. The contraction of the plate on

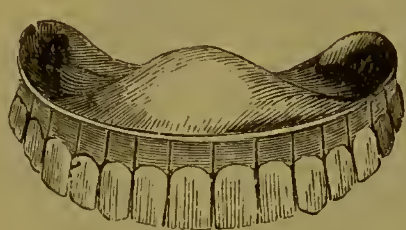

FIG. 1025.

FIG. 1026.

cooling is irresistible and may result in one or both of two accidents —chipping off the brittle edges of the teeth thus brought too closely together, or warping the plate because of the resistance which the teeth or blocks offer to the contraction of the plate. Thin letter paper slipped between the side joints will suffice to prevent these accidents.

Fig. 1025 gives an external view of a full upper set of single gum-teeth, arranged on a gold plate, preparatory to the operations which precede soldering, or other modes of fastening them to the base. Fig. 1026 is a similar view of a set of blocks, with a soldered rim covering the upper edge.

Usually, in first or temporary pieces, and sometimes after the alveolar absorption is completed, the fullness of the gum is such as to forbid the addition of an artificial gum to the ten incisors, canines, and bicuspids. In such cases the plate must be cut away from the front of the ridge as far as the first or second bicuspid, and the teeth ground with great accuracy to fit the gum itself. Single plain teeth will usually be best adapted to such cases; but an excellent effect can

sometimes be produced by grinding a block, when the shade of gum is well matched, to fit directly upon the natural gum. In partial cases the tooth or block must invariably be fitted to the gum; no plate should be seen above or at the side. In fitting directly to the plaster model this should be scraped (after the tooth is ground), so that it may press firmly on the corresponding gum.

The teeth or blocks being now arranged and fitted to the plate, the next step, preparatory to soldering, is to get access to the pins on the inside for the purpose of backing them. Set the articulating model on the table with the teeth upward; bend a strip of lead (an inch wide) outside the arch and about half an inch from the teeth; then fill the space with plaster, inserting a strip of tin foil opposite the median line, so that the plaster rim will readily break at that point when removed. In a double set do the same with each half of the articulator. When the plaster has set remove all wax or cement from the teeth and plate, and proceed to examine the pins, also the relations

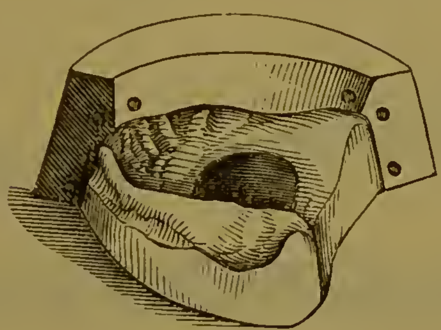

FIG. 1027.

FIG. 1028.

of the teeth or blocks to the plate and to each other. This temporary plaster band we regard as essential in every case, except a few varieties of partial sets. It is equally essential in vulcanite and other forms of plastic work, as will be hereafter explained. It is a common but not good practice, where the teeth are soldered, to substitute for this temporary band the soldering investment.

Fig. 1027 will give an idea of the shape of this rim, except that, being here designed for a different purpose, it does not show the impress of the teeth. Fig. 1028 represents the inner surface of a set of blocks with the wax removed, which we may suppose just withdrawn from the plate in the preceding figure. Blocks or sections are readily replaced in their proper positions; but single teeth are sometimes so similar, especially bicuspids, that they are apt to be misplaced. To prevent such accidents have a circular wooden block four inches in diameter, with twenty-eight cups or depressions, so marked that each tooth can be instantly put into and taken from its proper cup.

The teeth being thus arranged, a gold plate or backing large enough to cover the entire width, and from eight- to nine-tenths of the height of the posterior surface of each, is fitted to them in the following manner. Each tooth has securely fixed in the back part of it two platina rivets for the purpose of connecting it to the backing. Each backing, therefore, should have two holes punched through it by means of a pair of punch forceps, as represented in Fig. 1029, large enough to admit the rivets of the teeth. After having punched one hole a rivet is inserted; then by moving the strip of gold plate two or three times to the right and left a mark will be left upon it, indicating the distance the rivets are apart. But previously to this the rivets should be made parallel (being very careful not to strain them in the tooth) and the ends filed off level. Otherwise the pins will not

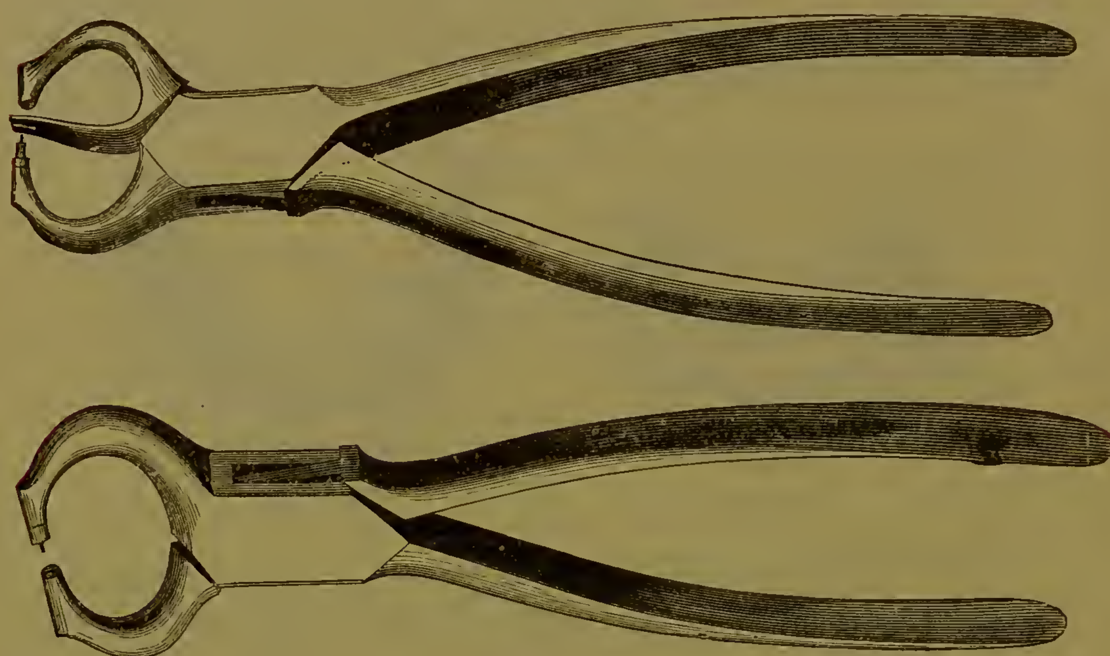

FIG. 1029.

go into the holes punched, and there will be an uncertainty as to which side of the pin the mark on the plate corresponds.

Dr. Samuel Mallet has very ingeniously invented a punch which will save much trouble in finding the proper position of the second hole (Fig. 1030). After straightening the pins, one is placed in the hole, *i*, at the head of the punch, the other pin pressing out the movable punch, *e* (which works by the spring, *g*), until it slips into the slot, *h*; the two punches, *f e*, then make the holes at the exact distances apart to receive the pins.

A simple form of punch, and one not liable to accident, is a piece of steel half an inch square and three or four inches long. It consists of two halves riveted together at the top, each tapering nearly

to a point. By turning a small screw, inserted midway in one leg, the points held opposite the pins are separated to their exact distance. A slight tap of the hammer marks this upon the backing, and then the holes are made with an ordinary punch. Pins often set very irregularly in a tooth; they should be parallel, but not necessarily perpendicular. Too much bending of a pin close to the tooth makes it more liable to fracture in soldering or by use in the mouth. Pins also

FIG. 1030.

vary much in thickness; it is better to have the pin of the punch forceps of medium size, and to ream with a broach for large platina pins. A set of broaches are indispensable in backing teeth and in many other operations.

The holes should be slightly countersunk on both sides, and after placing the backing on the tooth it is made fast by splitting with a strong knife or a wedge-shaped excavator the ends of the platina rivets or pinching them together with pliers. If the ends of the

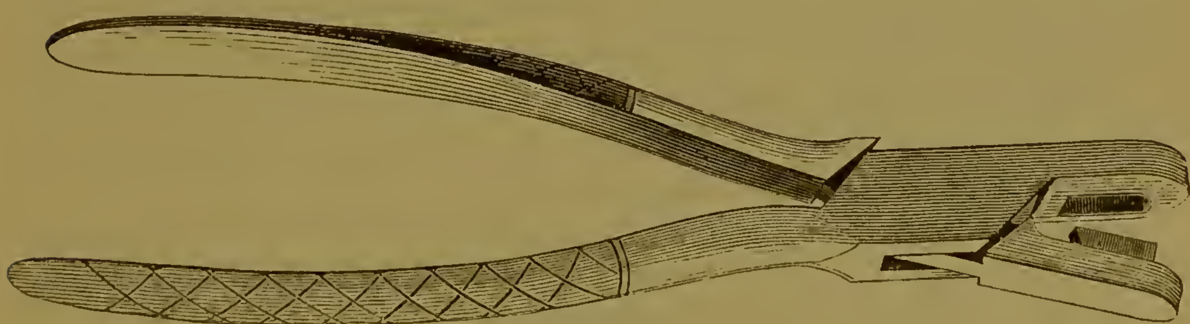

FIG. 1031.

platina rivets are hammered so as completely to fill the holes in the backings, it will prevent the solder from flowing in and uniting the two as firmly as it should do. The backings should be slightly hollowed before they are put on; by so doing they will fit up closely to every part of the back of the tooth. Fig. 1031 represents a pair of forceps designed to give a general form to the backing by punching it from a piece of gold plate of the required thickness.

After the backings have been made fast to the teeth they are to be accurately fitted to the plate, standing off from the plate enough for a very thin piece of watch spring to be passed under it. This shows that the tooth is not raised by the backing from its place in the investment. A much wider space makes the flow of solder uncertain; the practice of placing scraps of gold under badly-fitting backings is a very slovenly one; and where such imperfections occur it is much better to fill such spaces with gold foil.

Some dentists back the teeth as they grind and fit them and before investing; others invest with the plaster and sand, and back without taking them from the investment; others, again, partially invest with the soldering mixture, remove, and back the teeth, then replace, and add more plaster and asbestos or sand over the edges of the teeth. The last method is unsafe, because the two layers of batter are apt to separate in heating and may displace the teeth.

Backings (called also stays or standards) vary much in size, shape, and thickness. Some variations are matters of taste; as, whether they shall be rounded, square, or beveled at the top corners; whether chamfered to a thin edge, or left thick, and then beveled or rounded. But other points often considered optional are not so, inasmuch as they affect the appearance or stability of the work. Backings which cover the translucent edge of the tooth darken it by the refraction of the oxidized surface next the tooth, and which cannot be kept bright; even if it could, the gold would impart a yellowish tinge. They should cover enough of the tooth, and fit so accurately as to prevent motion of the tooth; for this will inevitably cause the pins, sooner or later, to break off. Backings, in relation to each other, must either be so far apart at their base that the solder will not flow from one to the other, forming a continuous band, or they must be in contact throughout whatever distance the solder will unite them. This rule is particularly applicable to backings of single gum teeth, which are often (perhaps usually) made the full width of the tooth up to the shoulder. This continuous band gives great stiffness to the plate. But the contraction of the solder will certainly warp it, unless prevented by actual contact of the edges soldered. In case of plain teeth a heavy, continuous line of solder will almost certainly warp the plate. A block may be backed for soldering in one piece, or in parts closely fitted, or in distinct backings opposite each tooth. A block much curved is with difficulty backed in one piece; long or thin blocks are liable to be cracked by the contraction of a backing, either in one piece or made continuous by soldering. Backings should be of the same gold as the plate, but heavier, especially if long or large.

Sometimes the shape of a gum or block tooth may require the

removal of the plaster rim, which can readily be done; then replaced after the backing is completed for the final adjustment of the teeth. The teeth are next to be fastened to the plate with a small quantity of cement (resin mixed with wax, or, still better, the wax, gum mastich, and whiting compound), and a small roll of softened wax (not melted or made adhesive) placed over the entire surface to be soldered. In Fig. 1032 the inner band may be taken to represent the width of this wax roll, which is of great service in preventing any plaster of the investment from getting accidentally upon the parts to be soldered. If the teeth have been previously soldered to the backings this wax strip should be narrower; but if rivets and backings are to be soldered at the same time, the rim must be made carefully to cover every point where solder is to flow. The plaster band is then very carefully removed and the piece surrounded with the soldering investment, which must be no thicker than is sufficient to protect the teeth and hold them in place. The wax and cement are easily removed, leaving the surfaces perfectly clean and ready for the borax and solder. The investment should not project so far over the inner edge of the teeth as to obstruct the blowpipe flame; it should not cover the lingual surface of the plate, nor should it be thick on the palatine surface. On the palatine side it might be well also to cut along the median line nearly or quite through the investment; the object of this is to give play to the lateral expansion of the plate, the antero-posterior expansion being usually, from the shape of the plate, sufficiently free. This we regard the simplest and best method to prevent warping of the plate, so often caused by the very means taken to prevent it.


FIG. 1032.

We have said nothing of fastening the teeth with a firm body of cement instead of wax, so as to try them in the mouth before soldering, because a correctly taken articulation makes this unnecessary. As remarked in the chapter on articulation, this process admits of perfect accuracy. Its very object is to prevent the necessity of any change in arrangement after teeth are adjusted. An error of articulation will often involve a change in the jointing of blocks more troublesome than the original grinding; in fact, neatly ground blocks (or gum teeth) will not permit the slightest change of position without fresh grinding somewhere. Trial of teeth, merely to test the correctness of articulation, may in some cases be especially necessary when used to test correctness in the selection of teeth; for it requires experience to en-

able us to determine, *a priori*, just what style of work is best adapted to the case. But the awkward and momentary retention of a plate to which the teeth are so slightly attached is no test of its esthetic correctness, unless the selection has been grossly misjudged. It is only after the patient has become habituated to the piece, giving time for the natural form of the lips and motions of the mouth, that we can best decide whether or not our work has beauty of expression as well as artistic finish.

Mr. Andrew Wilson, of Scotland, adopts the following method of backing teeth: After having partially fitted the tooth to the plate, take a piece of platina foil, as thick as can be used conveniently, and, pressing it against the tooth, perforate it where it is marked by the pins; then cut it into the required shape of the backing and press it as closely as possible to the back of the tooth. Apply a little borax to the platina pins which come through the back; then place the tooth, with its face downward, upon a thin piece of pumice, covered with dry plaster, putting upon the platina sufficient gold for the thickness required; slowly heat it, gradually raising the heat until the gold melts, when it will rapidly flow over the whole platina surface, uniting so firmly with the pins in the tooth that Mr. W. has never, during eight years' use, seen a case in which they have loosened, even where there has been sufficient violence to break the tooth. After the backing has been run and the tooth allowed to cool slowly, it is filled to the requisite thickness and shape; tooth and backing are then closely fitted and finally soldered to the plate. In arranging the teeth on the plate for soldering, Mr. Wilson uses an investment of white sand and plaster, equal parts, placing a thin strip of platina on the outside of the teeth, with a layer of the investment on both sides of it, so that, should the plaster crack in soldering, the platina may keep the teeth from shifting their places. The whole time occupied in heating and backing a tooth is about half an hour; when several are done at once a little longer time is required. Of course, all the backings of the set should be flowed at the same heating.

Instead of using the strip of platina plate to prevent the teeth from becoming displaced, in case the plaster cracks, thin sheet-iron rings one inch deep or iron wire may be used; but platina is undoubtedly the neatest, and has the advantage of being indestructible; it may be narrow and thin, so that its cost would form no objection to its use. But if the plaster is not in excess the investment will not crack. A batter made of three or four parts of asbestos to one of plaster will stand the hottest fire of the laboratory. Many prefer equal parts of plaster and sand, as forming a more solid investment in which to back up the teeth. Mr. Wilson's method might be improved, first, by

completely fitting the tooth before backing; secondly, by running the thin platina backing one-sixteenth of an inch on the plate, to any irregularities of which it can be quickly burnished down. This flange secures a very perfect and strong attachment to the plate, and is the method of backing (with heavier platina) sometimes practiced in the continuous-gum work.

Ordinary backings, after they have been fitted to the plate and held to the teeth by bending or splitting the pins, may be removed from the plate, set in a batter of plaster and asbestos, and soldered; the plaster should be so stiff as not to flow over the backings. The solder

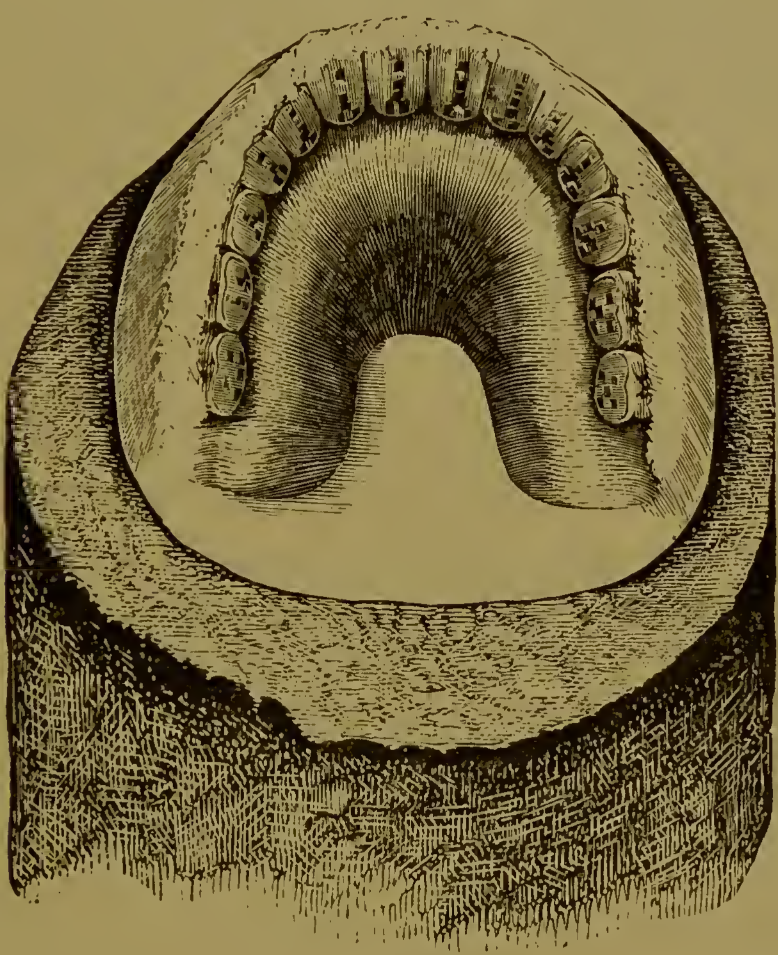

FIG. 1033.

should be rather harder to fuse than that used to fasten the teeth to the plate. The backings, after slowly cooling, should be filed, and may even be Scotch-stoned. Backings can be better and more quickly finished singly than when attached to the plate. This method, or Mr. Wilson's, is much to be preferred to the common practice of soldering the backings to both teeth and plate at the same heating.

A piece invested preparatory for soldering and placed upon a lump of solid charcoal is seen in Fig. 1033.

Directions for applying borax and solder are given in the chapter on

soldering. Some cut the solder into very small pieces; others use one piece to each tooth at its base, and a second for the pins unless previously soldered; in the figure the pieces are unnecessarily small. If the backings are soldered to the teeth beforehand a more fusible grade of solder should be used at the second soldering. The work must be very gradually and thoroughly heated up before directing the flame upon the plate or backings. The last point to be touched with the flame is the solder, and this not before a slight melting of the edge shows that it is just on the point of flowing. If every preparation for soldering has been properly made the actual flowing of the solder on a full piece will take less than a minute, and will be so smooth as to require no other finish than the Scotch stone and the polishing wheels. After soldering, the cover should be placed upon the soldering pan (Fig. 1054) and the work allowed to become quite cold before removal; when a charcoal lump (Fig. 1033) or pumice stone is used the work must also be covered while cooling.

CHAPTER XII.

PRINCIPLES AND APPLIANCES OF SOLDERING.

Soldering is the union of two metallic surfaces, either by slightly fusing the surfaces themselves (technically termed sweating, or autogenous soldering), as in the union of a plate of silver to a block of copper preparatory to rolling into Sheffield plate, or by the fusion of an alloy which melts more readily than the metals to be soldered.

The conditions of successful soldering are as follows:—

1. Careful and proper investment. 2. Careful cleansing of surface on which the solder is to flow; which implies absence of oxid. 3. Careful application of the flux and of the solder. 4. Careful heating up. 5. Proper amount and direction of heat in flowing the solder. One condition requires good solder; of this we have elsewhere spoken. To limit the flow of the solder and protect all places which it should not encroach upon, a thin layer of plaster batter or a solution of whiting may be applied with a camel's-hair brush. Another calls for the use of borax, the specific action of which, as a flux, is—first, the removal of existing oxid by virtue of its powerful affinity for it; secondly, the prevention of further oxidation by the exclusion of the oxygen of the air. Another condition demands a skillful management of the blowpipe flame; this is the principal difficulty with most beginners and, indeed, with not a few old practitioners.

The borax (flux) should be used in the lump and rubbed with pure (distilled or rain) water upon a coarsely-ground *glass* slab until a creamy paste is formed. Into this the pieces of solder may be placed, and also some of it applied with a small brush or feather to the surfaces over which the solder is required to flow. Hard water and the common practice of rubbing borax on a slate make it impure and to some extent interfere with soldering. Too much borax is objectionable, and gold requires less than silver. The solder is placed along the base of the backing, and if this is short the solder can be directed in its flow by the flame of the blowpipe to the holes of the pins; if the backings are long, it may be best to place a small piece of solder over the holes of the pins in addition to the piece along the base of the backing. The solder should be tested before using by melting it on a piece of silver plate.

In fulfilling another condition—the management of the heat—the following points demand attention: (*a*) To raise the heat very gradually, until the water of crystallization of the borax is slowly driven off; for if this is done rapidly the borax puffs up and throws off the solder; rapid heating at the outset is apt also to crack the teeth. (*b*) To diffuse the heat when using the blowpipe, so that the solder shall not become melted before the metallic surfaces are hot enough to unite with it, else it will roll into a ball or flow with an abruptly-defined edge; whereas it should unite so smoothly with the plate that, except for the difference in color, its line of termination cannot be detected. (*c*) To manage the fine point of the blowpipe flame so as to be able to direct the flow of the solder to any given point; the rule being that, unless prevented, solder will flow toward the hottest point. There are two kinds of flame given by the blast of the blowpipe: 1. The broad, heating-up, or oxidizing flame; this is produced by holding the tip a little behind or at the edge of the flame. 2. The pointed, soldering, or deoxidizing flame; this is produced by passing the tip more or less into the flame. A very general mistake is to use too strong a blast.

The apparatus required for soldering includes a lamp to give a sufficiently hot flame; a blowpipe to give intensity and direction to the flame; borax, brush, glass, slate, solder, and solder-tongs; investing materials and clamps to protect the teeth, also to hold the parts in relation to each other until soldered; a receptacle to retain or give additional heat during the process of soldering; an acid (sulphuric) bath to remove the glass of borax.

As accidents sometimes occur from the flame communicating with the explosive mixture of air and alcoholic vapor in the body of the lamp, it is prudent to make a *safety lamp* by connecting the wick tube

with the body of the lamp by a small tube which shall be, under all circumstances, full of alcohol. Figs. 1034 and 1035 represent such lamps. If the wick is not permitted to run below the shoulder above the horizontal tube this tube will remain always filled with alcohol. The top of the wick tube should be beveled off in a direction just the reverse of that shown in the drawing, so as to permit the downward projection of the flame. Fig. 1036 is a very ingenious modification of the safety lamp, made by Dr. B. W. Franklin, so constructed as to retain the alcohol uniformly at the same level.

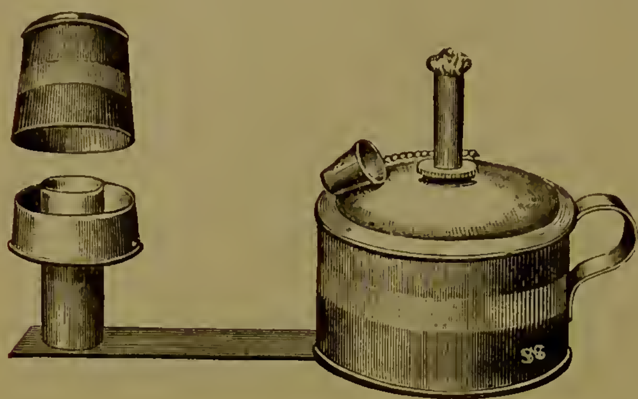

FIG. 1034.

The fluid used in these lamps is usually alcohol. For all purposes of dental soldering alcohol gives a sufficient degree of heat, and is much more cleanly than the carboniferous flame of ethereal oil, sperm oil, coal oil, or gas.

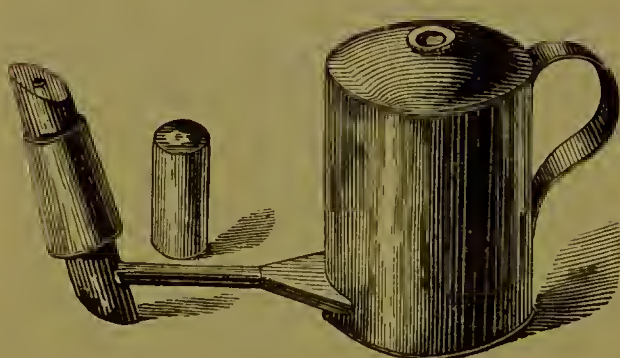

FIG. 1035.

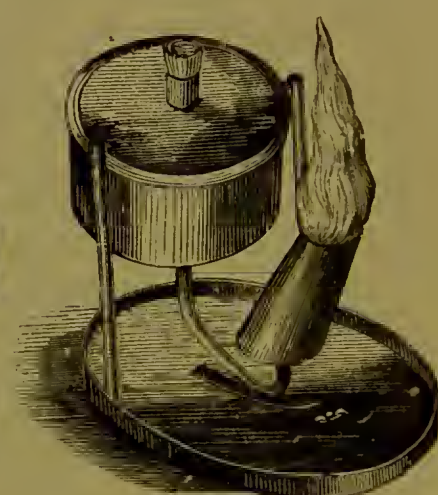

FIG. 1036.

To give intensity and proper direction to the heat of the lamp, a blowpipe is necessary. The simplest is a tapering tube, fifteen to eighteen inches long, and curved at the smaller end (Fig. 1037). At

FIG. 1037.

this end the bore for the last half-inch should be *perfectly* cylindrical and about as large as a medium-sized knitting needle. This

may be modified in several ways and made more useful: First, by cutting it within three inches of the flame end and inserting a small, hollow ball or cylinder, to receive the condensed moisture, which, in the plain blowpipe, often interrupts the blast. Secondly, by attaching a flattened mouth-piece, which is much less fatiguing to the lips to grasp. Thirdly, by connecting the flame end to the mouth-

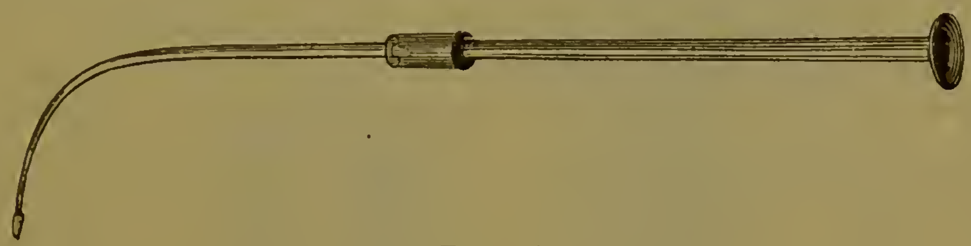

FIG. 1038.

piece by from six to twelve inches of flexible tubing. The flame end ought to be straight, and from four to six inches long; a cigar holder makes an excellent mouth-piece. A bulb or enlargement in the tube might be serviceable in retaining condensed moisture; but it is less liable to accumulate in rubber tubing than in the metal pipes. There are many forms of mouth blowpipes, and some quite expensive ones; but the pipe with flexible tube, as here described, will be found very convenient for the laboratory.

FIG. 1039.

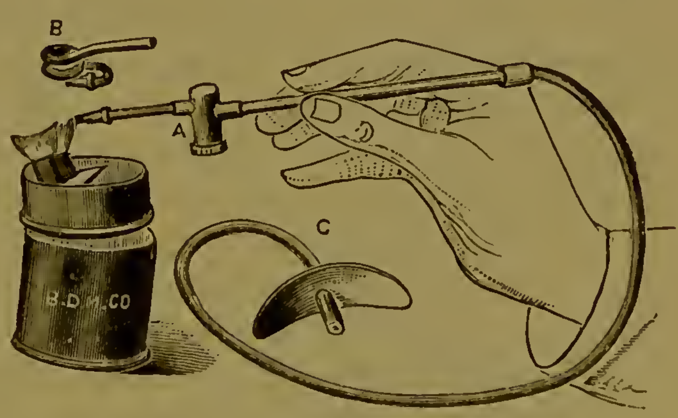

FIG. 1040.

Figs. 1038, 1039, and 1040 represent different forms of blowpipes devised for the purpose of preventing the moisture which accumulates within the tube from being blown from the orifice and interrupting the blast.

Figs. 1039 and 1040 are modifications introduced by Mr. Thomas Fletcher, and for the latter it is claimed that the mouth-piece is the easiest to use, and the heaviest continued blowing causes no strain on the lips, while the tongue has the necessary control over the opening. Being held as a pencil, the chamber on the stem stops all condensed moisture and prevents the heat ascending to the end.

The mouth blowpipe requires in its use a peculiar management of the muscles of the chest, cheeks, and palate, by virtue of which an

uninterrupted and regular current of air is thrown from the lungs through the pipe. The simplest way to learn how to do this is to first practice blowing exclusively during *in*spiration; this calls into action the cheek muscles and involuntarily closes the opening between mouth and fauces. Then use the pipe solely during *ex*piration; this teaches control of the chest muscles in the emission of a steady, gentle blast. The art of using the blowpipe without fatigue consists in alternating the action of these two sets of muscles; the art of giving a perfectly steady, uninterrupted blast implies control over these muscles and the ability to pass from one set to the other at the moment of opening or closing the entrance to the fauces. After persevering practice of the two methods of blowing, the art of connecting them will come almost unconsciously; when once learned it is never forgotten. Those who are too indolent to master the first difficulty of learning it become the slaves to mechanical appliances, which, however useful for many purposes, can never supply the place of this simplest and best of all blowpipes.

Blowpipes working by artificial blast may be divided into four classes: 1. Alcoholic or self-acting blowpipes; 2. Mechanical or bellows blowpipes; 3. Hydrostatic blowpipes; 4. Oxy-hydrogen or aero-hydrogen blowpipes. Of each of these we shall give an example. To enumerate all the forms that inventive talent has devised would fill too much of our space.

The SELF-ACTING blowpipes derive the force of their blast from the vapor of hot alcohol, which, igniting as it passes through the flame, adds to the intensity of the heat.

Small, portable lamps are made, of which quite a number of different patterns are to be found in the depots. The principle and general plan of construction are very clearly shown in Fig. 1041, designed by Dr. S. S. White. All alcoholic blowpipes give intensity of heat, but are greatly inferior to the mouth blowpipe in the control which the operator has over the force and direction of the jet.

The different forms of the MECHANICAL blowpipe are almost infinite. The principle of construction is either that of the bellows or the force pump, combined with a reservoir of air to give uniformity to the blast, which would otherwise issue in jets.

A common house bellows secured to the floor will form a simple and good arrangement. A spring should separate the handles, the upper one of which forms a treadle. An india-rubber pipe should pass from the nozzle to an air-tight box, from which a second tube comes out and is attached to the blowpipe. If the bellows is made double, like a blacksmith's, the upper half forms the air-chamber in place of the air-tight box.

Fig. 1042 represents the Burgess blowpipe, which is a convenient and efficient form. A is the cylinder of the pump, which is $2\frac{1}{2}$ inches in diameter, allowing a 3-inch stroke. B, piston rod. C is a heel-and-toe treadle for driving the pump. D, the receiver, 12 inches high by 3 inches in diameter, into which the air is forced. The whole height of the machine is 24 inches; the base is 12 inches by 5.

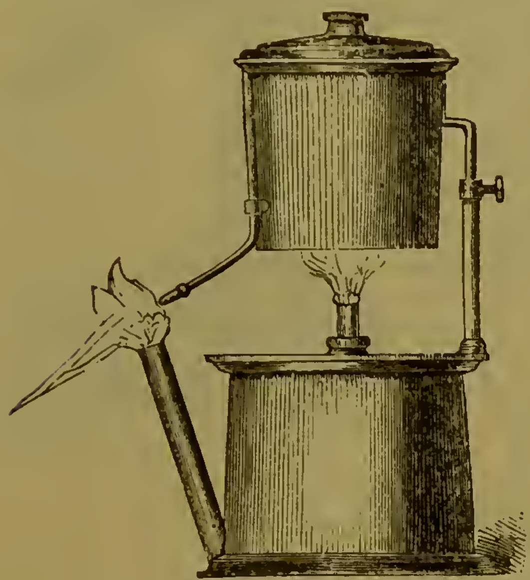

FIG. 1041.

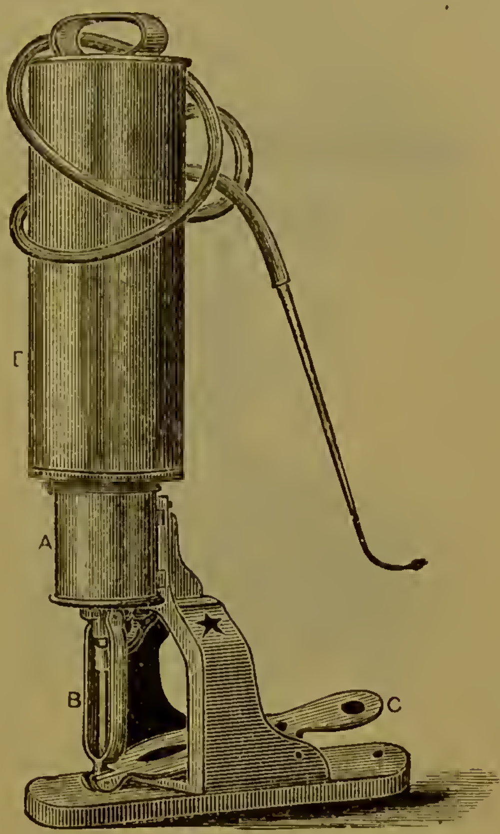

FIG. 1042.

Figs. 1043 and 1044 represent Fletcher's bellows blowpipes, capable of being adjusted in any desired position.

Figs. 1045 and 1046 represent two forms of the Fletcher automatic blowpipe, one of which is mounted on a ball-joint. These forms are

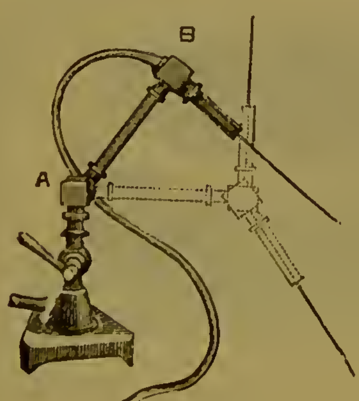

FIG. 1043.

FIG. 1044.

very convenient for soldering, especially in the manufacture of gold crowns and bridge-work.

Fig. 1047 represents a style of foot bellows by which the bellows and automatic blowpipes are operated. Fig. 1048 represents a carbon

block for use as a support in soldering. It is a perfect non-conductor and much cleaner than charcoal. Fig. 1049 represents a carbon cylinder, the cupped end of which answers as a good support for small cases, such as crowns, while soldering.

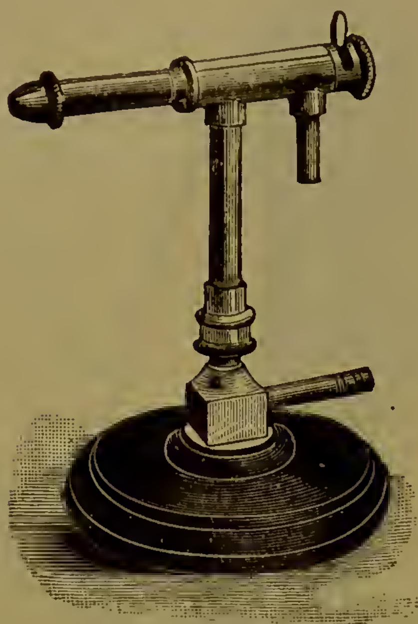

Fig. 1045.

Fig. 1046.

Fig. 1050 represents Macomber's gas blowpipe. The direction of the point, 1, is regulated by the joint, 3, and the supply of gas controlled by the stopcock, 2. The air is supplied from the lungs,

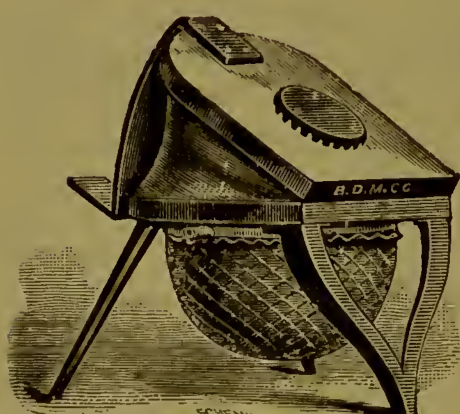

Fig. 1047.

Fig. 1048.

Fig. 1049.

or from some form of mechanical or hydrostatic blowpipe, through the flexible tube.

Fig. 1051 represents an automatic blowpipe to be worked by a foot-blower or bellows.

Fig. 1052 represents a hand blowpipe, into which the air is admitted at A and conducted through a small tube to the upper end

of the gas-pipe, B. The supply of both gas and air is regulated by pressure of the thumb or fingers on the rubber tubes, C. C.

The THIRD class of blowpipes is sometimes combined with the second to regulate the blast, or with the first to intensify it. In its uncombined form it consists essentially of a blowpipe point attached by a flexible tube to an air-chamber, from which the air is forced by the steady pressure of water. When once set in operation, it is self-acting, and in this respect has great advantage over the second class. This, with the perfect regularity of the blast, makes a properly constructed hydrostatic blowpipe much the best of all substitutes for the lungs and mouth blowpipe.

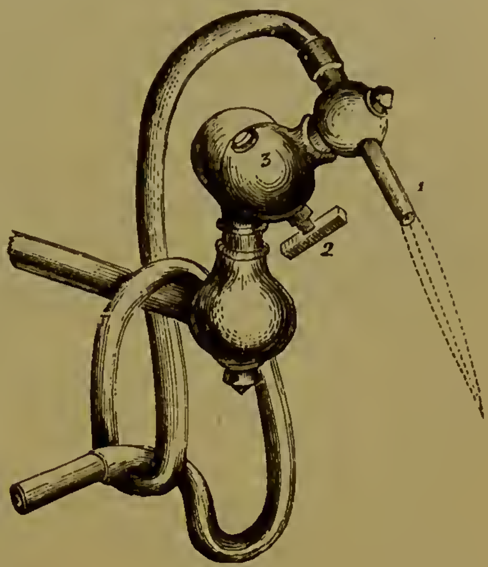

FIG. 1050.

The gasometer of the nitrous oxid gas apparatus makes a very excellent hydrostatic blowpipe. Its form, and the manner of using it, are so familiar to dentists as to render any illustration or description unnecessary. Any required force of

FIG. 1051.

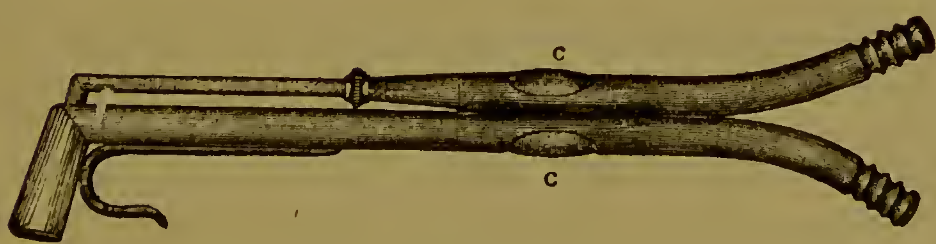

FIG. 1052.

blast may be given by detaching the counterpoise, or by adding weights to the descending cylinder.

The fourth class of blowpipes is analogous in its operation to the

oxy-hydrogen blowpipe. The point is double, consisting of a tube, through which comes the supporter of combustion (oxygen or common air), surrounded by a cylinder, through which comes the combustible (alcoholic vapor, illuminating gas, or hydrogen). In Count Richmont's aero-hydrogen blowpipe the hydrogen is generated in a vessel by the action of dilute sulphuric acid upon zinc, and the air forced through the center tube, either with a bellows or from the lungs. The heat is less intense than that of the oxy-hydrogen blowpipe, but is too great for most laboratory purposes. The gas blowpipe is a very convenient instrument; the principle is similar and the heat very great.

Fig. 1053 represents an ingenious oxy-hydrogen blowpipe invented

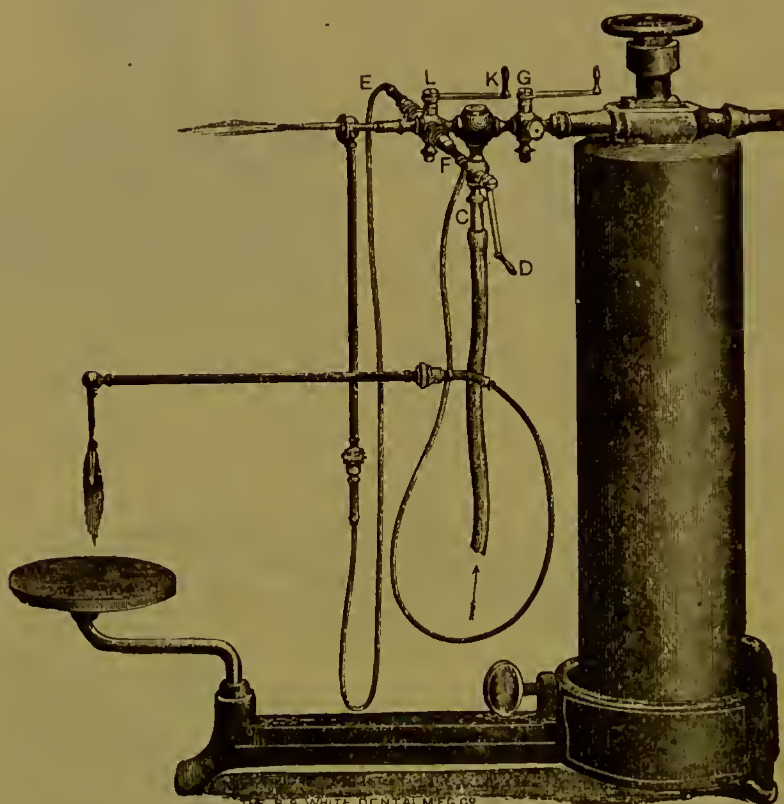

FIG. 1053.

by Dr. J. Rollo Knapp, which consists of an iron stand in which is secured, by a thumb-screw, a 100-gallon cylinder of nitrous oxid gas. By means of a yoke and set-screw the valve of the cylinder is connected with the tubes and valves of the blowpipe in such manner that the proportions of the mixture of nitrous oxid and illuminating gases are under perfect regulation and control.

There are two pipe-nozzles, which may be used at the same time, or one at a time, according as a large or small flame may be desired. One pipe-nozzle is shown as hung upon its hook, and the other as if directed upon work held on the pivoted bracket-table. It can be

used wherever illuminating gas is available. Any of the soldering operations of the laboratory, from the largest piece of crown-work to the most delicate joining of the narrowest bands or finest wires, are accomplished with equal facility. With illuminating gas of good quality and sufficient pressure a pennyweight of 20-carat gold can be melted in thirty seconds. A large investment must be heated first by other means.

The apparatus consists of the blowpipe attachments, connected to the yoke of a nitrous oxid gas-cylinder, the cylinder being set upright, and secured by a thumb-screw on one end of an iron base or stand, at the other end of which is pivoted a table upon which to rest the work. The blowpipe proper is a continuation of the outlet-tube of the gas-cylinder. A lever-valve, G, regulates the supply of nitrous oxid. Just beyond this valve is the mixing-chamber, K, to which the illuminating gas is conducted from the gas-bracket by means of rubber tubing, entering the bottom of the chamber through the valved tube, C. The lever, D, controls the supply. The mixing-chamber is provided with a gauze screen to prevent the flame from being drawn into the supply-tubes. Immediately beyond the mixing-chamber the pipe is branched to afford two flames of different sizes, E and F, which can be used independently of each other or both together. The valve-lever, L, regulates the flame in both. For greater convenience in manipulation the pipe-nozzles are connected with the branched pipe by rubber tubing. From the body of the valves, L, an arm extends, at the end of which is a small scalloped disk as a holder for the flame-nozzles when not in use. In the illustration one of the nozzles is shown in the holder, the other being directed to the revolving table.

In the operation of soldering the parts to be united must be held together in their exact relative positions. This can sometimes be done by simply laying them together; but usually they must be held in place, either by iron wire bound around them, or by small clamps of iron wire, or by rivets; or else by some investing material, which, in dentistry, is always plaster mixed with some substances that will counteract its tendency to shrink and crack under soldering heat. This substance may be coal ashes, soapstone dust, feldspar, clean sand, or asbestos. The two latter are the best, and may be mixed in proportions varying from 2 to 6 parts sand or asbestos to 4 of plaster. As a rule, the less plaster, the less shrinkage; but a very small quantity makes the investment too friable.

A common mistake is to use too large a quantity of investing material. This almost invariably results in the warping of the plate; for, as all investments have some degree of permanent contraction, and all metals must expand, if the latter is bound by a rigid, unyield-

ing mass it will inevitably warp. Hence, as a rule, use no more investing material than is necessary to keep the parts to be soldered in their position and to protect the porcelain surfaces from direct contact with the flame. This subject will be further considered when speaking of the soldering of teeth to the plate.

In selecting a suitable receptacle for the work to be soldered, it is important to retain the heat, especially when using the mouth blowpipe. A funnel-shaped mat made with scraps of woven iron wire, or a large lump of pumice stone, or one of close-grained charcoal, with the outside coated over with a thin layer of plaster, form very simple and convenient receptacles for smaller pieces of work. For larger work, or for very high temperatures, it is important to receive addi-

FIG. 1054.

tional heat from ignited charcoal, for which purpose the soldering pan (Fig. 1054) is a very admirable contrivance. The movable lid remains during the heating up and the cooling off, but is, of course, removed during the act of soldering.

Fig. 1055 represents the form of soldering blocks which are made of either plumbago or asbestos.

After soldering the work should cool gradually, unless it is to be re-swaged. If there is any porcelain attached the cooling must be very gradual. When cold, it may be placed in dilute sulphuric acid and slowly raised to the boiling point, kept there for a few moments, and then slowly cooled. This dissolves the glass of borax, which is so hard that it injures the edge of files and scrapers.

A few general considerations may be of service in the use of the above-described appliances for soldering. It is an operation regarded by many as attended with much risk; and by students generally it is considered the *pons asinorum* of dentistry. Whereas, there is no process in dental prosthesis in which the desired result can be with more certainty obtained, provided such care and skill are exercised as alone can give success in any department of the art.

Plates warp from want of support when heated or from excess of investing batter; they are burnt, blistered, or melted from careless or ignorant use of the blowpipe. Teeth are broken from rapid heating or cooling; they are displaced by the shrinking of an ill-judged investment. Solder is condemned because it will not bridge a chasm one-eighth of an inch wide, will not run over plaster, will not attach itself to an oxidized surface, or will obstinately roll up into a ball rather than flow over a surface too cold to receive it. These and all other vexations of soldering are the result of haste, ignorance, or want of skill. If there should be spaces under the teeth or backings, which, however, should always be avoided if possible by adapting the teeth in grinding to the surface of the plate and having the backings of a proper length, such spaces should be filled with gold foil. As much of the surface of the plate should be exposed as can be done by trimming away the plaster without affecting the stability and safety of the teeth, so that no obstruction is present to the flame of the blowpipe; this direction is especially applicable to a lower denture either full or partial. Good soldering depends upon the perfect heating up of the investment and plate, so that the solder can be brought by the heat of the blowpipe flame as near the melting point of the plate as possible without injury to the latter.

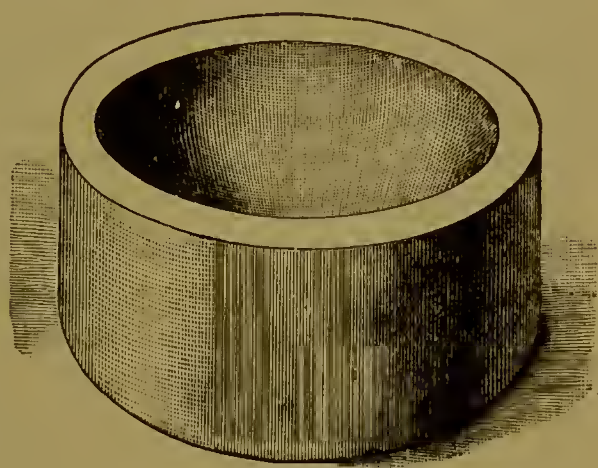

FIG. 1055.

In soldering two surfaces, as in the doubling of lower or shallow upper plates, the borax must contain no particles preventing contact of the plates; also the heat must be directed on the side opposite the pieces of solder, so that when melted it may flow between the plates from one side to the other. Clamps are preferable to plaster batter for holding parts together, whenever practicable, as in soldering a wire or band around plates; but when the relation must be preserved with utmost accuracy, as in clasps, the plaster investment is essential. It is

also necessary for the protection of porcelain from the direct action of flame.

In soldering teeth to a plate the batter must have such proportion of plaster with asbestos or sand as to admit of being used in small quantity, and yet be so strong when heated that it will not crack and endanger the position of the teeth. Backings and clasps must fit accurately wherever they are to be fastened. There should be no trace of plaster on a surface where solder is to flow; or, in fact, substances of any kind except borax, and not too much of that. Borax must be pure and clean, and used with soft water, and the heating must be gradual, in view of its liability to throw off the solder. Solder must be of good quality and carefully placed, never putting two pieces where the position will allow the proper quantity to lie in one piece. It is a very common practice to cut solder into very small pieces under the idea that it will flow more evenly; but if a plate is properly heated and the blowpipe flame skillfully managed the large pieces melt instantly and flow into their proper position.

It is quite possible, by careful observance of these directions and by expertness in the management of the blowpipe, to solder any set of teeth, bridge- or crown-piece, so that there shall be no roughness or abrupt edges requiring the use of files and scrapers. In fact, these tools are never needed to give finish to a perfectly soldered joint; the natural flow of the solder takes a shape which cannot be improved.

Finishing Process.—When the piece is cold it may be placed in water to soften the plastic investment, which should be carefully removed from the teeth; the set is then placed in a glass or porcelain vessel containing a mixture of equal parts of sulphuric acid and water, and heat applied. As soon as the borax (which, by the process of soldering, has lost its water of crystallization and assumed a glassy hardness) is decomposed, the vessel is removed and allowed slowly to cool. This process is termed by jewelers "pickling," and requires from ten minutes to half an hour for its completion, according to the strength of the acid and the quantity of vitrified borax on the plate. After this the acid is washed from the piece; or it is still more effectually deprived of acid by boiling in water containing a little caustic soda.

In removing the roughness which may have been occasioned by imperfect soldering, care must be taken not to cut away too much of the plate. For this purpose scrapers, files, and lathe burs are used, according to the position and quantity of surplus solder. Fig. 1056 represents a set of solder burs for trimming off superfluous solder. After the work has been made as smooth as possible with scrapers, etc., it should be rubbed with pieces of Scotch stone and water until

every scratch is removed; some use a fine, smooth cork attached to the lathe, and charged with water and powdered pumice or silex. The piece is then polished with Tripoli, applied by means of oil or tallow to a brush wheel (Fig. 1060), which is made to revolve rapidly

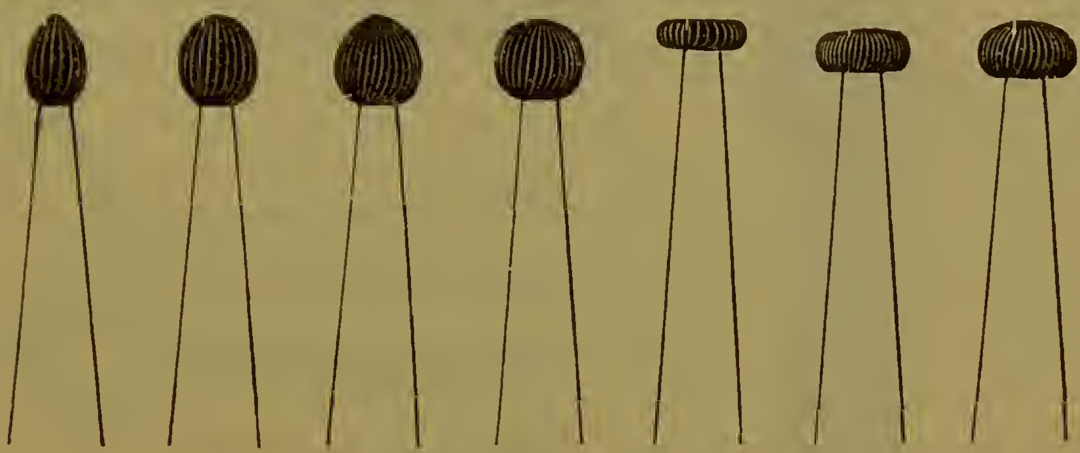

FIG. 1056.

against the work. Felt, rubber, walrus leather, and cotton wheels and cones are also employed in polishing. Fig. 1057 represents a felt wheel and cone. Fig. 1058 shows one of the various forms of vulcanite burs for carrying polishing powders. As to the rapidity with which a lathe should be worked: drills and burs require a slow move-

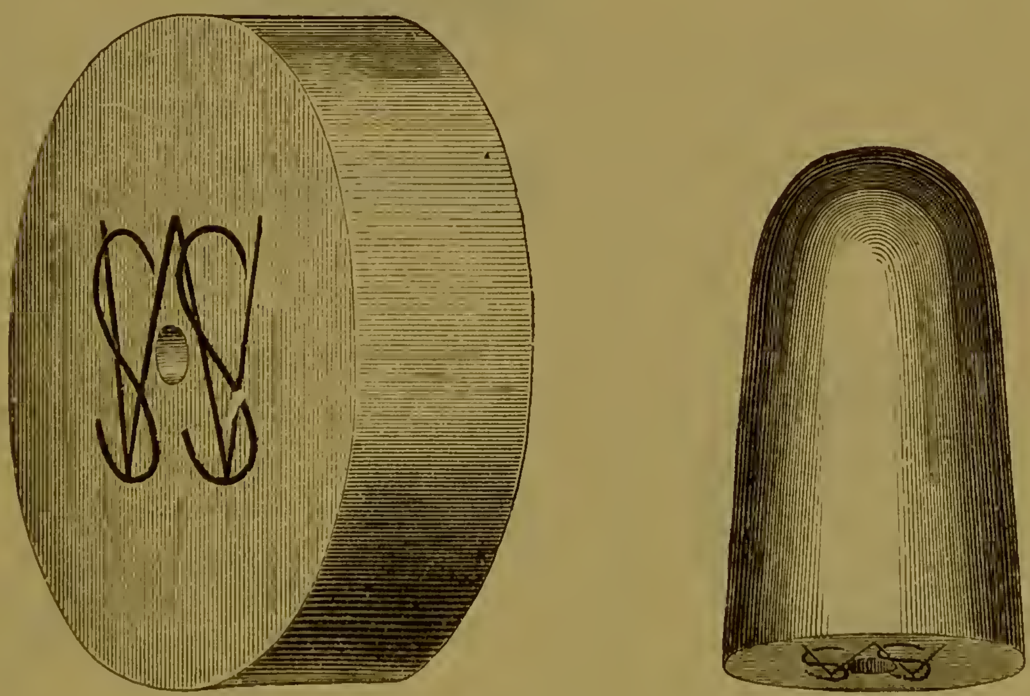

FIG. 1057.

ment; corundum wheels a quicker one; rotten stone a rapid motion; and whiting, zinc-white, or rouge the most rapid of all.

The piece may now be placed in a porcelain vessel containing the following mixture: niter, 2 ounces; salt and alum, each 1 ounce—

dissolved in 4 ounces of water. After boiling for half an hour in this to decompose the copper from the surface-layer of the solder and plate, it is boiled a few minutes in a solution of 1 ounce of caustic soda in 4

FIG. 1058.

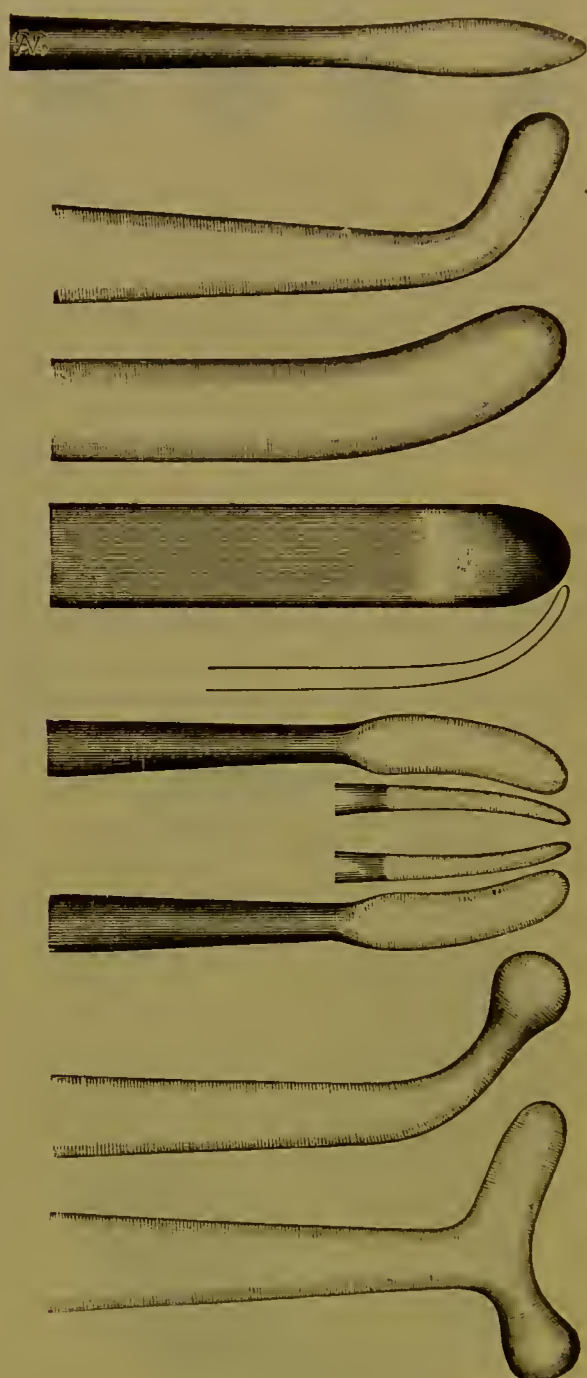

FIG. 1060.

FIG. 1059.

ounces of water to neutralize the acid, then washed with a brush in pure water.

The removal of the copper from the surface of the plate gives to the gold the beautiful orange hue, which is its natural color, and which it

will retain until the friction of mastication wears off this surface. The secretions of the mouth will fail to tarnish it; and it will be free from the disagreeable taste of which so many complain who wear artificial teeth set on metallic plate. But when plate is made from coin without alloy, or is 20-carats fineness, and the solder has a corresponding quality, the pickling process may be omitted.

The process of finishing is completed by polishing every part of the lingual surface of the plate, backings, and clasps with highly tempered and finely polished steel burnishers. Fig. 1059 represents various forms of plate burnishers. They should be frequently rubbed on a piece of wet Castile soap, and carried backward and forward in the same direction over the plate until every part of the gold exhibits a high polish. Burnishers of different shapes are required for different parts of the work; bloodstone burnishers are also used.

A piece, however, can be polished in less time, if not more perfectly, with brush wheels (Fig. 1060). Brush wheels vary in diameter, thickness, and material. Bristle wheels vary in stiffness and length of bristle; the stiffer being used for Tripoli or rotten stone, the softer for whiting and rouge. Cotton is often substituted for bristles; buckskin or felt are also much used for wheels or circular "laps," and are especially useful in dressing up the recesses of a plate. It is of the utmost importance that wheels or laps used for different polishing substances should be kept entirely separate; a little Tripoli or pumice powder on a rouge wheel may render useless the work of an hour. The brush should be set on the spindle of the lathe, then lightly smeared with suet by holding a small piece against it while it is revolving. The rotten stone is applied in the same manner, and with the brush thus charged, the polishing may commence; but the plate must not be exposed too long to the friction, as it will rapidly wear away the pure gold surface brought out by the pickle; hence some use only the burnisher or rouge after pickling. Tripoli has a sharper grit and cuts more rapidly than the ordinary rotten stone; but the latter gives a very smooth surface, and will in most cases give a sufficiently brilliant finish without rouge. A very high watch-case finish can only be given by very rapid revolution of wheels or buffers, charged with the finest quality of rouge, wet with alcohol. The piece must be previously washed with soap and water, so as to remove every trace of oil. Sometimes rouge is applied on a piece of soft buckskin, wrapped or sewed around small, blunt-pointed pieces of cork or wood. The lingual surface of the plate is the only one that should be polished. The dead color of the palatine surface throws out the polish of the other side and greatly improves the appearance of the piece. The adhesion of a plate is frequently improved by roughening the plate

with a file or by engraving lines upon it. The process of finishing on a gold piece, properly soldered, is a very simple matter, and one of secondary importance. A set with Scotch-stone finish is in every respect as useful and esthetically as beautiful as the most highly polished plate. There is, however, no objection to this sort of appeal to the eye, provided it is not the chief merit of the work.

There are three methods adopted for the retention of dental plates, and many modifications of form required by the various circumstances of different mouths. An enumeration of all the required forms would be impossible in this work; but we hope to represent a sufficient variety to enable the operator to decide which is best for any given case. We think it far more important, however, to endeavor to explain, as far as can be done, the principles which determine these different forms and modes of retention, than to lay down any set of didactic formulas for unreasoning adoption.

CHAPTER XIII.

RETENTION OF BASE PLATES—THEIR SIZE AND FORM OF OUTLINE.

THE utility of a piece depends largely upon the firmness with which it keeps its place during mastication or in conversation. The means adopted to secure this are fourfold: The first two retain the plate by extrinsic support; the last two depend upon an intrinsic quality of the plate itself. 1. Spiral springs, by constant pressure, keep the plates of a double set in position. 2. Clasps, by grasping some natural tooth, hold a partial piece firmly in place. 3. Spring plates, which are constructed of vulcanized rubber, and are available only in partial cases. 4. The close adaptation of the plate, whether of a full or partial set, causes it to adhere with a force which is lessened, first, by the amount of air between the surfaces; secondly, by the liability to displacement. These modes of retention will be considered in the order named.

FIG. 1061.

Spiral springs, formerly very much used, are now seldom employed; they are applied only to double dentures. Fig. 1061 gives a correct

idea of the position of the springs, their points of attachment, length, and direction of curvature. Fig. 1062 represents the detached portions of the spring, consisting of standards, screws, tangs, and spiral coil. The tendency of the curved spring to straighten presses each plate upon the alveolus, acting at the points of attachment of the standards. These points are chosen, first, in the uppper jaw, as nearly as possible on the line of equipoise, which will be somewhere between the centers of the second bicuspid and of the first molar; secondly, in the lower jaw, where a vertical line from the upper standard meets it. Perforated bicuspids and molars are sold, adapted to such cases; and the usual plan is to attach the standards before soldering the teeth. A more accurate method is to determine the position of the standards after the pieces are finished. The presence of the teeth makes soldering of the standards more troublesome, but not impossible; they may also be riveted to the outer rim of the plate. With the diamond drill holes can be made through the teeth or blocks opposite each standard.

Directions for making the coil have already been given; they are

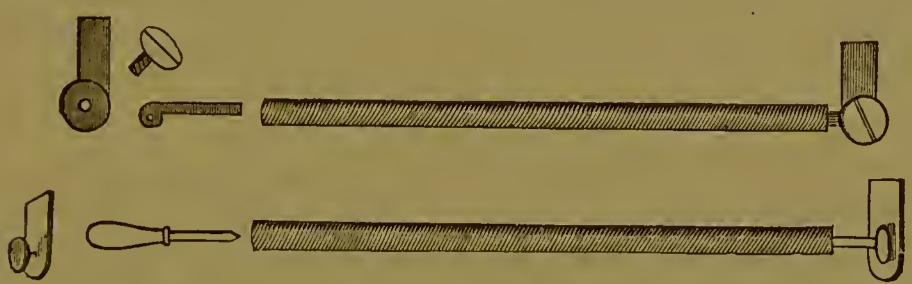

FIG. 1062.

usually purchased ready made. Their length must be such that the curve will not irritate the ascending ramus of the lower jaw. If too stiff their forcible pressure will irritate the gum; if too slight they will fail to keep up the piece. The tangs are held in the coil by closeness of fit; when loose they may be tightened by floss silk. The screws represented in the figure are troublesome to make, and are very apt to loosen. A better plan is, to pass a headed pin through standard, tang, and tooth, and rivet or solder it in the backing. This plan makes the tang permanent; the pieces are separated by detaching the upper or lower tangs from the coils. It adds greatly to the strength of the pin to pass it through the tooth or block. There should also be a shoulder on the standards to limit the movement of the tang; else the springs, by too great upward or downward motion, may irritate the mouth. It is unnecessary, in view of the present limited use of springs, to describe other and very ingenious methods of attaching them.

Dr. I. I. Stedman has devised a new form of springs for dental plates. Fig. 1063 represents the Stedman springs.

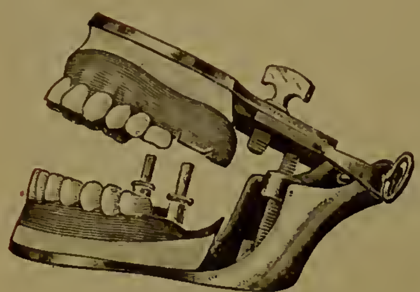

Fig. 1063.

The use of springs is now confined, first, to very flatly-arched upper jaws, usually small, covered with hard membrane, and having the attachment of the facial muscles close to, or quite upon, the ridge; also to lower cases where all trace of the ridge is gone. Secondly, to pieces inserted so soon after extraction that the rapid absorption will quickly destroy the adaptation. We shall speak elsewhere of other means adapted to meet these exigencies, in failure of which spiral springs are to be used. But they are troublesome to make, annoying to wear, diffcult to keep clean, and liable to accident; hence we only use them as a last resort. In conclusion, it should be noticed that the upper plate of spiral-spring pieces does not cover the palate, but is shaped more like the lower piece. This is one of its compensating advantages; for it is an objection to the otherwise valuable principle of atmospheric pressure that it covers so large a portion of the mucous surface.

CLASPS.

This method of retention, necessarily applicable only to partial pieces, has fallen into much disfavor, and given place to methods in lieu thereof which are really more objectionable. But, like many other time-honored practices which modern dentistry has thrown in its waste-basket, there are very decided advantages in this mode of retention, which make it in certain cases the best possible one. The disuse of clasps has grown out of, first, their injurious effects, due to improper construction and injudicious application; secondly, the difficulties of making a clasp piece. We venture the assertion that one-half the dentists do not really know how to make a perfectly adapted clasp piece; and that of the remaining half two-thirds will not take the trouble. The tediousness of clasp adjustment is out of place in that rapidity of manipulation demanded by the cheapness of modern dentistry. Nor can we expect to see the easily made but ineffectual vacuum cavity give place in turn to the clasp attachment, which it has to such an extent superseded, until the profession becomes awakened to the necessity of substituting good work for fast work—economical high-priced work for expensive low-priced work; until the mechanician so far respects himself as to value his labor more than the cost of his materials, and ceases to use certain substances because they are cheap, rather than others because they are better.

Next to pivoting, the clasp is the most secure of all methods of attaching artificial teeth in partial cases. But it is not universally applicable for reasons hereafter stated. In deciding upon the propriety of using clasps, the remaining teeth must be carefully examined to determine whether, in shape, position, texture, and relation to other teeth and to the proposed plates, there are many which admit of being clasped. If there are such teeth, a perfect impression of them is necessary; then greatest accuracy in fitting the clasp; lastly, a most exact adjustment of this to the plate, to which it is to be fastened with great care. Scrupulous observance of these points, in connection with a properly fitted and shaped plate, will take from clasp work the force of the objections urged against it.

In the selection of teeth to be clasped the points for consideration are: 1. Their condition: never clasp loose teeth or those where there is much alveolar absorption; or, if possible to avoid it, those which have filed surfaces. 2. Their shape: avoid all conical teeth, such as third molars and canines; also teeth considerably larger at the grinding surface than at the gum. The proper shape for clasping is the cylinder, or rounded prism; and only so much or such part of any tooth should be clasped as has this shape. Hence it is that thick, narrow clasps are best, because few teeth have much breadth of cylindrical shape. 3. Their position: incisors, canines, and third molars must be rejected for this reason; and second molars are unfit, if the plate holds incisor teeth. The incisors and cuspids are of all the teeth less suited for the attachment of a clasp. It is exceedingly difficult to apply clasps to these teeth in such a manner as to retain even a single tooth with sufficient stability to be worn with any degree of comfort. We remember once to have seen a case in which a central incisor (natural tooth) was inserted and kept in place by a gold wire projecting from each side of the tooth into holes drilled into the adjoining teeth. A stage of dental progress that permitted such a process might also have allowed the clasping of incisors; but we know of no possible circumstances that will justify, in the present state of dental art, the clasping of any of the six front teeth. No lower teeth should be clasped; but in some cases a stay (half-clasp) may be used. The best teeth, in respect of position, are the second bicuspids; next, the first molars; thirdly, the first bicuspids; and lastly, the second molars. These eight teeth are the only ones that should ever be clasped; and if possible the choice should be confined to the first four. 4. Their relation to the plate and to the other teeth. Let the clasped tooth be as near the line of equipoise as is consistent with other considerations. For incisors alone we should, for this reason, give preference to the first over the second bicuspids; and in case of

the loss of the ten or twelve anterior teeth we should use no clasp on the remaining molars. Teeth not decayed should never be separated from others with which they are in contact for the purpose of passing a clasp. If no other tooth can be found a stay (half-clasp) must suffice.

Observance of the conditions above enumerated restrict very much the range of cases that admit of clasps. In the matter of position and relation to the plate, circumstances may compel a choice not the most favorable to success; but in other respects it is far better to dispense with clasps than to apply them so as to incur risk of failure or injury to good teeth.

The liability to decay of the tooth around which a clasp is applied is always greatly increased by the removal of any portion of its enamel. The application of clasps to diseased or loose teeth always aggravates the morbid condition of the parts, and causes the substitute, which they keep in place, to become a sort of annoyance to the patient. Besides, such teeth can be retained in the mouth only for a short time, and when they give way the artificial appliance becomes comparatively or entirely useless; and even before their loss it is not held firmly in its place. Its instability exposes its presence to the observation of the most careless observer, and this motion is injurious to all the teeth near or against which the piece comes. In the lower jaw parts of sets are much less frequently called for than in the upper, and when they are, the use of clasps may be dispensed with altogether. A clasp can seldom be applied advantageously to a lower molar. The lower front teeth are least liable to decay of any in the mouth, and therefore do not require replacement, except in full sets, unless lost by a blow or by the destructive action of salivary calculus. A partial lower front piece calls for half-clasps or stays; but other partial lower pieces (replacing bicuspids and molars) should not depend for their stability upon any remaining bicuspid or cuspid.

If the injurious effects liable to result from the application of clasps to teeth selected according to the rules given could not in any way be counteracted, dental substitutes retained in the mouth by this means would, in the majority of cases, be productive of more injury than benefit; but they may be in great measure prevented. They are not caused, as many have erroneously supposed, solely by the mechanical action of the clasps upon the teeth, but also by the chemical action of the secretions of the mouth and decomposing particles of food. The method of measurably preventing these deleterious effects is twofold: First, to prevent the chemical action, the removal of the artificial teeth and thorough cleansing of them and the natural organs; this should be done every night and morning, and the teeth rubbed with a

brush and waxed floss silk until every particle of clammy, vitiated mucus and foreign matter is removed. The inner surface of the clasps should be freed from all impurities, and the whole piece cleansed with a brush and water. Secondly, to prevent or lessen the mechanical action the clasp should, as before remarked, fit with great accuracy the parts of the tooth protected with hard enamel; the whole piece should have such closeness of adaptation as to prevent motion of the clasp upon the tooth. We have elsewhere spoken of other injurious consequences of clasps placed too near the gums or exposed necks. Rapid decay and breaking off of the teeth, inflammation of the gums, of the peridental membrane, destruction of the alveoli and loosening of the teeth, are among the common results of the clasping of teeth as it is too often practiced. Consequences such as these have led many to an unqualified condemnation of this method; yet, as we have said, when suitable teeth are selected for clasping, and the work is properly executed, it is the best and most durable way in which a partial piece can be secured.

Shaping and Adjusting Clasps.—The gold employed for clasps should

FIG. 1064.

be about one-third or one-half thicker than the plate, and as wide as the cylindrical portion of the crowns of the teeth to be fitted. Some clasps are best made of half-round wire, and narrow; others may be broader and thinner; thick, narrow clasps are more universally applicable. In quality it is better that clasp and plate be the same, except when the plate is of pure coin. In this case add copper (but no silver) to give elasticity. Platina, often used for this purpose, imparts too much brittleness, after the piece has been worn for some time. Some may fit the tooth close to the gum; but in other cases the shape of the tooth, absorption of the alveolus, or morbid sensitiveness of the neck, forbid this. Enamel surfaces best resist the wearing action of clasps; dentine, exposed by the file or chisel, is more liable to abrasion or decay; cementum should in no case be brought in contact with clasp or plate. If the clasps chafe against sensitive parts, inflammation of the peridental membrane may be set up, followed by wasting of their sockets and ultimate loss of the teeth. Fig. 1064 represents a clasp bender.

With the plate in position in the mouth, a wax impression may be taken; the plate, adhering to it, on being withdrawn, will have a correct relation to the teeth which are to be clasped. Others adopt the less accurate method of adjusting the plate to the original plaster model. But as, for reasons before given, it is advisable to cut off the teeth from the model used in molding, a second model is necessary, and usually for this purpose a second impression. Moreover, if the mouth has marked irregularities or rugæ, and the plate covers much surface, it cannot be fitted upon a plaster model so as to hold the same precise relation to the teeth as when in the mouth.

When accurately fitted, clasps may be at once soldered on the model, or may be attached to the plate by means of a small piece of wax or cement composed of one part wax and two of resin, or gum-shellac, or sealing-wax, or softened modeling composition; these should be softened or melted and applied to the plate and to the inner side of each clasp. The plate and clasps thus united are carefully removed from the plaster model and laid with the convex side downward on a piece of paper. Plaster is then poured on the upper side of the plate, covering it and the clasps to the thickness of half an inch. After this has set the piece may be taken from the paper, placed on charcoal, the wax being softened and removed, and prepared for soldering.

This is the simplest way of fitting clasps to the plate and preparing the piece for soldering. Fig. 1065 shows the usual form of clasp; but when the clasp teeth deviate from a vertical position, or when the teeth are of such a shape that the wax impression does not copy them accurately, this method is in such cases not reliable. The clasps must be fitted to the teeth in the mouth, instead of on the plaster model, and may then be attached to the plate as just directed. Often only one can be attached at a time, and after this has been soldered the piece is replaced in the mouth, and the other made fast to the plate. The greatest care is necessary to prevent altering the position of the clasp in taking the piece from the mouth.

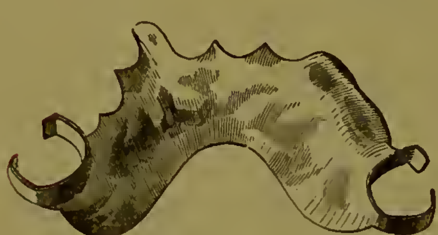

FIG. 1065.

The following is Dr. Fogle's method for securing accurate adaptation of the clasps. They are first fitted to the plaster model, leaving the ends straight. A narrow strip of plate about five-eighths of an inch in length is used as a temporary fastening, one end of which is soldered to the lingual surface of the clasp; the plate and clasp are now both placed on the model (made from impression taken while the plate is in the mouth), and the other end fitted and soldered to the

plate, forming a sort of semicircle or bow. Fig. 1066 represents the plate, clasps, and temporary fastenings on the plaster model.

The clasps are now adjusted to the model; however accurately this is done, it will be found, on applying the plate to the mouth, that they will not fit the teeth there. After properly adjusting them the temporary fastenings will be found sufficient to hold the clasps in their exact position while the piece is being removed. This done, it may be invested, placed on charcoal, and the other steps connected with the process of permanent soldering gone through with, detaching the temporary fastenings when the investment has fixed the clasps in position.

Dr. Cushman advises, in very difficult cases of adjustment, as where the clasp teeth are much inclined, and where you have to fasten to second molars, a slight modification of this plan. After soldering one

FIG. 1066.

end of the strip to the clasp, and having bent the other to touch the plate when on the model, put both in their proper place in the mouth; then, with a sharp-pointed instrument, indicate the point where the bow touches the plate; place them on the model again; adjust the end of the bow to the point marked; confine it there and solder fast. Dr. Cushman considers Dr. Fogle's method of adjusting clasps so valuable that he never ventures to set clasps permanently, even in the simplest case, upon the original model with the plaster teeth as the only guide for position.

Dr. Lester Noble's method is as follows: Place the plate in the mouth, and let the clasp bind upon the tooth with only sufficient firmness to keep it in its proper place. Then mix a small quantity of plaster from a lot which, by previous trial, you find requires four or five minutes to set; put it upon a piece of paper or sheet lead about

an inch square, and just before it begins to harden introduce it into the mouth upon the forefinger, pressing it into gentle contact with a portion of the plate and about one-half of the clasp. It must be held there for three or four minutes, until it is sufficiently hard to break with a sharp fracture; this point you can determine by examining the plaster left in your bowl. The plaster must then be withdrawn. Sometimes plate, clasp, and plaster will be brought away together; or the plaster and clasp together, leaving the plate; or the plaster will separate, leaving both clasp and plate in the mouth. Should the plaster by any accident break, it can readily be united at the point of the fracture, without in the least altering its shape—one great advantage over wax. If the plaster adheres to the plate on withdrawal from the mouth, it must then be carefully detached, the plate replaced, and the same process repeated for the second clasp; or possibly the impressions for both clasps can be taken at once.

Several precautions are necessary. If the clasp bind too tightly around the tooth its ends will when removed spring together; and thus it will not exactly fill the original impression made in the plaster. If the part of the clasp which you design to cover with plaster be so regular in shape as to make its adjustment when out of the mouth uncertain, mark it with a file or a small point of solder; this will be copied in the plaster, and remove all doubt as to its definite position. If the plaster be extended over some part of the edge of the plate, it will, in the absence of any marked irregularities of surface, give a better guide for its readaptation. Lastly, if the plaster cover too much of the clasp tooth, it will be more liable to break on being withdrawn.

Take now the clasps, place them each in their separate impressions in the pieces of plaster, securing them if necessary by a small piece of softened wax. Place one end of your plate in its corresponding bed in one of the plaster pieces. If proper care has been used, both clasp and plate will fit into the plaster with unerring accuracy, and, of course, hold the precise relation as when in the mouth. While in this position cover the clasp and the under surface of the plate with fresh plaster, or plaster and sand or asbestos; when this has hardened remove the first plaster, just as in other cases you would remove the wax, preparatory to soldering.

The methods of Drs. Fogle and Noble may be thought too tedious for cases where the shape and position of the teeth are such that a wax impression will accurately copy them; but in the great majority of cases it will be found essential to accurate adjustment to resort to one or other of them. Sealing-wax or shellac may also be used to retain the clasps in position until they are soldered to the plate.

If the clasp stands off from the tooth on its coronal edge, the food

is apt to pack into the wedge-shaped space and loosen it, or even change its shape; if on the edge near the gum, it gives lodgment to the food and mucous secretions, to the injury of the tooth. Dr. Spalding recommends, as a preventive against such lodgment, to use in all cases thick, narrow clasps; to attach them by two or more standards (Fig. 1067), if the clasp is long; to put them well up on long teeth, and on short teeth to cut away the plate. In this way most of the neck is exposed to the cleansing action of the tongue.

The close adaptation of the clasp to the surface of the tooth is too often neglected. It is commonly done with round pliers, making trial from time to time upon the tooth of the model. This is an uncertain method in any case, and in many utterly worthless. Prof. Austen advised always to take a separate plaster impression of the teeth to be clasped; for which purpose a small partial impression tray is used (Figs. 939 and 940). Let the plaster get quite hard; then slightly open the impression; withdraw it and close up the fissure. Make from this either a plaster or a fusible-metal tooth; if the former, harden it with soluble glass. With round pliers and a hammer clasps can be fitted with great exactness to such a metallic tooth. Extreme accuracy of fit may most easily be obtained when the contour of the tooth is irregular by the following method: burnish down to the tooth a strip of very thin platina; then on the outside of this strip lay pieces of gold (of the fineness suitable for clasps), with borax, and flow them with the blowpipe.

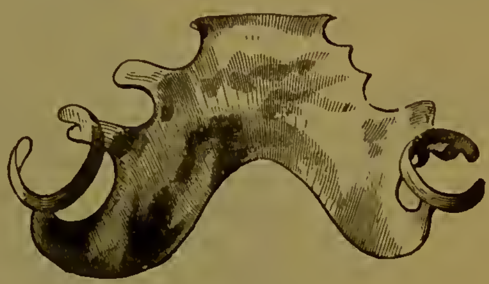

FIG. 1067.

A common error in soldering clasps is to make their union to the plates too wide. Clasps are often called springs, but if soldered through nearly their whole length they become rigid stays, devoid of elasticity. Fig. 1068 shows the proper extent of clasps embracing the posterior natural teeth. There should always be a proportion between the size of the clasp and the width of its attachment; in no case should it exceed three-sixteenths of an inch, and one-eighth of an inch is ample for most cases. When practicable the two arms of a clasp should be of equal length; but in short clasps it is sometimes preferable to throw all the elasticity into a single arm. A single attachment is better than two, as it gives more play to the arms of the clasp in the slight unavoidable motions of the plate. Again, in shaping the plate, cut it well off from the tooth, allowing a tapering tongue to extend up the clasp for its attachment. In clasp pieces and in all partial pieces remember that the plate should come in contact with the

teeth it approaches, or else stand as far off as the case will permit; the narrow band of gum so often left between plate and teeth is liable to irritation by compression between the two; this is productive of more annoyance and injury than the direct contact of the plate against the tooth.

Partial Clasps or Stays.—These differ from clasps in the absence of elastic arms grasping the tooth. Taking a short, rounded prism (triangular in case of bicuspids, in molars quadrangular) as the "type" of a clasp tooth, the clasp proper must grasp a side and two angles or two sides and three angles. If it lies against two sides and one angle, or if two opposite sides are so inclined (in the line of the clasp) that it will not take hold, then it becomes merely a stay (Fig. 1069).

Stays demand for serviceable action a *point d'appui;* hence they must be in pairs—lying either against the two teeth bounding an

FIG. 1068.

interdental space, or against teeth on opposite sides of the mouth. They have great value in all partial cases where there are no isolated teeth suitable for clasps. Their function is to give stability to the plate by preventing lateral motion. When the bicuspids or molars have inclined or bulging inner surfaces the stays hold the piece after the manner of a clasp, the elastic force being given by the plate. This result can only be obtained, however, by a very carefully taken plaster impression when a vulcanite plate is made, or in case of gold plate by getting the exact relation of the parts by Dr. Noble's method. It is a mistake to attempt forcible retention of a plate by the lateral thrust of stays; any such pressure causes the teeth to yield, and then the stays can only act as in the cases first given.

It will be observed that when the stay on each side is double, as in

Fig. 1070, it not only prevents lateral motion, but the points between the teeth prevent backward motion. The stability given in this manner by stays, taken with an exact adaptation of the plate, is far more trustworthy than that given by any form of vacuum cavity.

In connection with clasps we shall briefly notice two methods occasionally practiced for the retention of plates. First, by the pressure of wood against the tooth. This method was formerly much used when human or ivory teeth were set on bone. Stays were carved in bone (see Fig. 1070); or metallic stays or clasps were riveted, or grooves and cavities were cut, holding slips of some hard wood which pressed against the teeth. This method was applied by Dr. Stokes to metallic plates—soldering gold tubes to the plate near the teeth so that the end of the inserted wooden pivot, slightly projecting, pressed on each side of the tooth selected.

Seeondly, by drilling into one or two sound roots of incisors, canines, or bicuspids a short canal, and lining it with a gold tube. Corresponding pins soldered to the plate keep it in place much as stays do; if the roots permit deep canals they may retain it with consider-

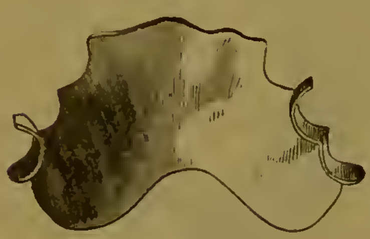

FIG. 1069.

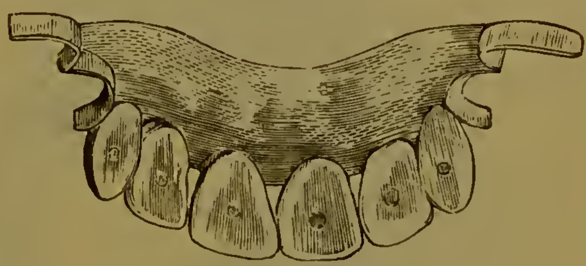

FIG. 1070.

able force. Such a pin may be used in combination with a clasp or stay. Directions given in chapter on crown and bridge-work easily explain how to prepare and attach such pins. In some cases it may be desirable to use such a pin in place of a clasp or stay, but the plate must cover enough mucous surface to give stability. We question the propriety of subjecting the roots of two incisors to the strain of five or six teeth on a plate of this kind.

When the teeth have recently been extracted and it is designed to construct an artificial denture before much change has occurred from absorption, the front portion of the plate should terminate within the outer border of the alveolar ridge, and the edge be scalloped to correspond with the festooned surface of the gum over the cavities from which the natural teeth have been removed.

Size and Outline Form of Special Cases.—It is impossible to enumerate all varieties of clasp pieces, nor could we delineate under each variety any one form as absolutely best for all its sub-varieties. The more philosophical course is to find if possible what principles,

mechanical and physiological, determine the best form in any case, and to illustrate by a few examples the application of these principles.

Upper Incisors.—The plate must not cover the front of the alveolus, so that on front or side views of the mouth its presence can be detected. This rule applies also to canines and front edges of bicuspids. The model at these points should be scraped, so that the corresponding die shall give a shape which will sink into the gum. The plate must also be filed to a thin edge before grinding the tooth. With these precautions a tooth or block may have the support of the plate under the center of its base. Otherwise it becomes necessary to cut the plate along the line of the backings; and this is in some cases the best plan. Incisor teeth, if firmly bedded in the gum, may trust for stability to their hold in the standards, provided they have been properly fitted and soldered.

The size and shape of plate between teeth and clasps will depend upon the number of incisors, position of clasps, presence or absence

FIG. 1071.

FIG. 1072.

of other teeth, and upon peculiarities of the mouth or of the patient. For the application of the principles already given to these several conditions we shall select a few particular cases.

One Incisor.—A central or lateral should not be attached to a first molar on the same side by a plate clasped as in Fig. 1072 without an additional clasp or partial stay around one of the bicuspids, as in Fig. 1071, in order that the leverage between the clasped and supporting tooth or teeth may be lessened. It is also desirable to have the plate extend some distance back of the tooth around which the clasp passes. When three or more natural teeth intervene between the clasp and artificial teeth the latter form is preferable, because there is no possibility of irritating the teeth by the plate or by mucous deposits. It will be noticed that the curve of the plate is opposite that of the dental arch, thus giving proximity to the teeth only where it is unavoidable. A lateral incisor, cuspid, or bicuspid may be applied in the same way;

and if the second bicuspid or first molar is unfit, from its shape and from decay, to be clasped, the plate may be extended to the second molar, or it may be even carried across the mouth and clasped to a plate on the opposite side; but these modifications are suggested only in cases of necessity. Such plates may be made very narrow if strength is given by increased thickness; but too narrow plates are open to the objection of allowing the attached tooth to bed itself too deeply under the pressure of mastication. When the form in Fig. 1071 is adopted it is usual to direct soldering a wire or band along the festooned edge to give strength. A much better plan is to gain strength by thickness of plate, and to chamfer the plate along this edge. The thin edge protects the gum equally well, does not wear the teeth more than the thick one, and has the decided advantage of giving no space for lodgment of food.

This plate will permit attachment of clasp to the molar and to either of the bicuspids, accordingly as one or other of these may be best for clasping. Decision in this case is based on principles which apply to many other cases. Supposing the three teeth well shaped and sound, the molar is firmly implanted by its trifid root, and permits complete encircling with the clasp; but it is further from the incisor; hence there is more strain upon tooth and clasp. With the clasp to the second bicuspid, the plate having the same length as before, we have the best possible application of its retentive power; it cannot, however, pass around the outside or front angle of either bicuspid, consequently the clasp does not have so firm a hold on the tooth. The same remarks apply with even more force to the first bicuspid. There will usually be some modifying circumstances to determine in this class of cases choice of the clasp tooth.

Two or Four Incisors.—Two incisors may be attached to a plate shaped as for one (Fig. 1071), with the addition of a second clasp, or partial stay, when the teeth will not permit of a full clasp. But much the best practice is to select the second tooth on the opposite side. Fig. 1073 gives the form when it is decided to run the plate up to the intervening teeth. With four incisors and clasps on second bicuspids, the form represented by Fig. 1073 is best, because only two teeth lie between the incisors and clasp; and it is better to carry the plate up to the teeth than to expose so small a portion of gum. For four teeth the plate should be rather wider than for two.

In these cases a closely-fitting plate assists so much in its own retention that bicuspid stays will often suffice to retain them, or a clasp on one side and a stay on the other. When the adhesion of the plate to the gum is thus partly relied upon it is not necessary to make the plate for four incisors larger than in Fig. 1073.

When the four incisors and the cuspids are to be replaced the construction of the plate (Fig. 1073) is upon precisely the same principle as the preceding, the only difference being that the plate should be rather larger and extend further back than the clasped teeth. When the teeth on one side of the mouth are too much decayed, or are incapable of affording a secure attachment, or are missing, even this num-

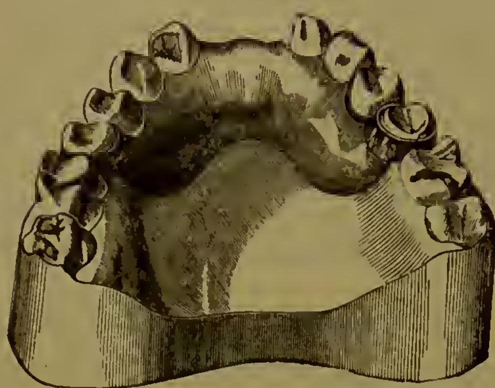

Fig. 1073.

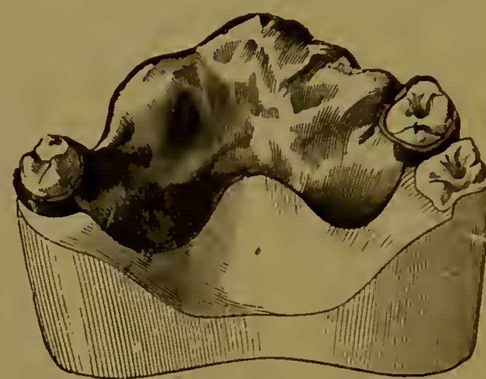

Fig. 1074.

ber of teeth may be held by a double clasp on one side of the mouth and .a stay on the other. But the plate should be extended half or three-fourths of an inch back of the tooth to which it is clasped. If this precaution is neglected, the piece, from its weight, may act as a lever upon the tooth and loosen it or cause periostitis. It sometimes happens that a piece made originally with clasps on both sides of the mouth loses the benefit of one clasp from the loss of the tooth; and yet the patient retains it in place as well as before. The piece is then in part retained by the fit of the plate to the gum; from which we learn that if only one clasp or, what is better, a double clasp can be attached to a plate with from four to six teeth, it is advisable to cover rather more of the surface of the mouth. In this combination the clasp and stay gives steadiness, and the close fit of the plate to the gum gives adhesion.

Fig. 1075.

Upper Bicuspids.—One or two bicuspids on one side are often attached to a plate about the size of a half dollar, clasped to the bicuspid or molar behind. But such pieces are not of much service in mastication. It is better practice to leave such a space unfilled than endanger the durability of a good tooth by clasping it. If there is a bicuspid space on either side the plate crosses the mouth. Fig. 1075

represents such a plate clasped to the first molars and fitted, as is very commonly done, closely to the incisors. But in this and all other cases where the four or six front teeth remain, if the plate does not fit closely to the palatal necks of the natural teeth, it is decidedly better to leave as large a space between the plate and the teeth as possible. The strength of the plate is preserved by giving less curve to the back edge, or by doubling the plate in the middle. The design of this form is to leave uncovered as much of the roof of the mouth as is possible.

An important point is gained by having the plate fit closely to the teeth and mucous membrane immediately back of the natural front teeth, and also by having the edge of the plate made thin. The articulation of the dental letters (the mutes T, D, Th, the nasal N and the liquid L) is thickened by a plate which is left thick at such a part, or not well adapted to the mucous membrane and the teeth.

When the loss of bicuspids is accompanied by that of the six front teeth, and the first molars alone remain, a good form of plate is shown in Fig. 1074. The backward extension of the plate, curving partly over the alveolus, is designed to prevent the weight of the piece from acting injuriously on the molars and to assist their retentive power. If the second molars are also in the mouth, the extended plate must be differently shaped. If the molars are well shaped and firm the plate may be narrower than here represented, being careful to make it thicker also. But if the presence of adjacent molars prevents the use of complete clasps, or if their form renders stays necessary instead of clasps, the plate may be rather wider. Be careful, however, not to cover the hard floor of the palate, or to attempt giving, by a cross band at the back of the plate, the stiffness which is best gained by thickness of metal.

Plates of this class are kept in place as much by the adhesion of contact with the gum as by the clasps. In many cases the force of adhesion is such that the lateral support of stays is quite as effectual as clasps. Hence, after a clasp piece of this kind has been worn for some time and become perfectly set to the mouth, it may be advisable to shorten the clasps into stays; indeed, it is better practice, in all cases, to anticipate this ultimate fit of these plates and make stays at first instead of clasps. This applies with still more force to the loss of twelve teeth, the second molars remaining, which should in no case be clasped; stays may very properly be used to prevent lateral or backward motion of the plate. The presence of these second molars, by giving lateral steadiness to the plate, prevents all necessity for covering the hard palate, and makes a vacuum cavity wholly uncalled for. A solitary molar should never be clasped, nor should it be allowed to remain in the mouth.

Alternate Spaces.—It remains to consider the forms of plates for vacancies alternating with natural teeth. The forms given for four incisors will answer for all alternating vacancies anterior to the second bicuspids, remembering to make the plate wider in proportion to the number of teeth, and thicker in proportion as it is made narrow; also, that a first bicuspid may in many of these cases be clasped with better effect than a second or than the first molar. Fig. 1076 is a good type for cases where the vacancies include the bicuspids; notice in this cut the backward extension of the plate. Where the natural teeth are in groups of two, it is best to carry the plate close up; if as many as three or four are together, the plate may be cut away, especially if they are incisors. Fig. 1077 represents an exceptional case, in which two laterals and two left bicuspids are attached by clasping to the right first bicuspid and molar. The left molars are supposed to be loose, or sockets much absorbed, or from some other cause forbidding

FIG. 1076.

FIG. 1077.

clasps or stays. In this case the undue strain on the clasp teeth will ultimately cause their loss. Whenever an unavoidable strain of this kind is thrown upon a tooth a clasp may be used in preference to covering the palate, provided the patient is content, for the sake of the firmness which it gives, to risk the loss of the tooth. Teeth are more firmly retained by clasps than by atmospheric pressure, and this, with many patients, outweighs all considerations of injury to the other teeth.

Partial pieces with alternating spaces do not acquire that adhesion by contact found in cases where the lost teeth lie together. The interrupted margin between the teeth so readily admits air under the plate on the slightest motion that the atmospheric pressure is imperfectly applied. Hence there is continued demand for the retentive power of the clasps. The vacuum cavity does not correct this difficulty or supply the place of clasps, since, as will be explained in the

next section, the vacuum acts on soft membrane and has necessarily a temporary force.

When the six or eight front teeth remain, a plate holding bicuspids and molars cannot be retained by clasps. In the first place the cuspids could not be clasped, nor would it be proper even to carry stays against them. In the latter case the weight and leverage of the piece would be too great for the slight clasp that a first bicuspid permits; but two stays, with the points passing as far to the front of the bicuspids as the cuspids allow, would tend to prevent the slipping of the plate backward.

Lower Partial Pieces.—These do not properly come under the head of clasp work. Fig. 1078 represents a reinforced partial lower plate for supplying bicuspid and molar teeth on both sides, the six anterior natural teeth remaining in the mouth. The anterior portion of the plate is extended upward on the lingual surface of the natural teeth, which adds to the strength and acts as partial stays for the retention of such dentures. Additional strength may also be given by doubling the anterior portion of such a plate. In replacing one or more incisors lost by accident or calcic deposits half clasps may be applied to the bicuspids. For such cases the best style of work, beyond all question, is a vulcanite plate, made on a model from a plaster impression. Fitting with great accuracy the inner surfaces of the bicuspids, it is firmly held without injury to the retaining teeth. Partial pieces filling bicuspid and molar vacancies should not clasp cuspids or bicuspids; the position of remaining molars seldom permits clasping; even stays cannot always be applied. Artificial crowns may be inserted to support a clasped plate and gold crowns may be attached to roots and badly decayed teeth to support clasped plates, and thus save more valuable teeth from the strain and wear of clasps.

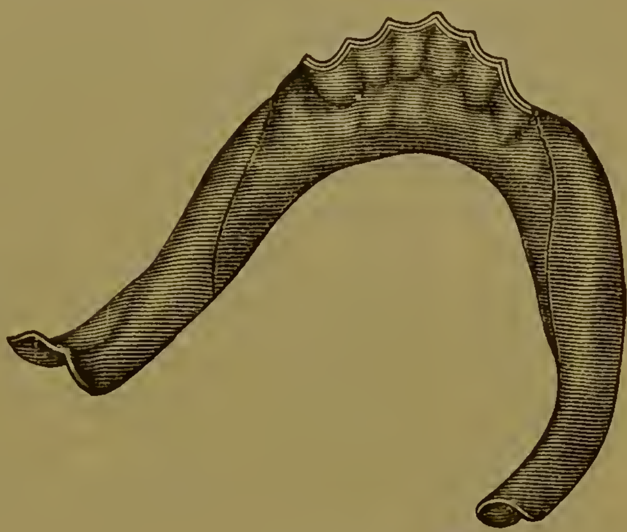

FIG. 1078.

In chapter fourth, on Preparatory Treatment of the Mouth, the question of extracting molar or bicuspid teeth which might otherwise be used for clasping is considered. The importance of permanence of the work outweighs any temporary advantage resulting from clasping one or two such teeth. In chapter third, and in the section on Retention by Clasps, are many remarks which it is unnecessary to

repeat, but which are important for the full understanding of the details of construction given in this section.

PLATES RETAINED BY ATMOSPHERIC PRESSURE.

Of the two methods of retaining a dental appliance already considered, the first, by springs, is suited only to entire dentures; the second, by clasps, is adapted only to partial cases. The principle of retention now to be considered is applicable to both; where practicable it is the most perfect way of retaining a set of artificial teeth. If the pressure of the atmosphere could be removed from the mucous side of a plate, allowing its full force to be exerted upon the lingual surface, the smallest plates would adhere with a force of four pounds, the largest forty. But, for reasons to be given, plates seldom have one-fourth of this resistance to displacement. There are two methods in present use for securing the service of atmospheric pressure. One is by close adaptation of the plate; the other by construction of a cavity of definite form. Both act by the more or less perfect exclusion of air from between the plate and the mouth. The first will be considered as the Adhesion of Contact; the second as the power of the Vacuum Cavity. Before describing the separate application of these to dental plates, a few remarks are necessary in addition to what has already been said in the last section of the third chapter, in exposition of the general principles of atmospheric pressure.

The surfaces of two pieces of highly polished ground glass, if pressed together, will adhere firmly; so much so, sometimes, as to resist every attempt at separation. Surfaces less smooth and close-grained will also adhere with great tenacity if their pores or irregularities are filled by wetting with water. If both surfaces are rigid they may be made to slide upon each other, but will resist a force of five to fifteen pounds for every square inch if applied at right angles to the surface; if one surface is soft and pliant it becomes difficult to keep it in contact around the edges. Traction upon the center, as in the case of a disk of wet leather upon a flat stone, will draw in the edges and create a vacuum in the centre. It might be supposed that in this vacuum space lies the power that raises the stone; whereas it lessens the power by reducing the area of stone in contact with the leather, even if the vacuum is perfect. Still, if the entire circumference is in contact no air enters the cavity except what passes through the porous leather, and for a time the lifting power of the disk is sufficient to raise the stone. If traction be made upon the disk anywhere but in the center the flexible edge will be raised; air enters between the surfaces and counteracts that pressure on the under side of the stone which was the lifting force.

Hence between two surfaces adhering by simple contact, one of which is soft and pliant, adhesion is not so persistent as where both are rigid, because of the liability to separation around the edges admitting air between the surfaces. Applying this to dental plates we may understand their liability to become detached by a degree of motion which separates them from the gum at any one point around the edge. We learn also that so long as absolute contact is maintained we have the most perfect exclusion of air practicable; hence no force of adhesion in a limited vacuum cavity (the perfect exhaustion of which is impossible) is comparable to the adhesion of the entire surface of the plate, provided this is made as perfect as possible by accurate workmanship and is not weakened by the admission of air around the edges.

If we exhaust the air from the barrel of a key and apply the lip, it will be drawn in and held with a force sufficient to support the weight of the key for some time. This simple experiment will prove, on examination, very instructive. The mucous and submucous tissues are pressed into the key because the fluids pervading these parts, being under pressure in every other direction, tend toward the point from which the pressure is wholly or partially removed. The extent to which the lip is drawn into the key will depend upon two conditions: *First*, the softness and mobility of the tissue; *secondly*, the shape of the edge of the orifice. If in addition to these two points we inquire, *thirdly*, why the key after a time drops off, we shall, from this simple illustration, have fully explained the rationale of the vacuum cavity, as applied for the retention of a piece of dental mechanism.

First: the extent to which or rapidity with which a partial vacuum becomes filled up by any yielding tissue with which it is brought in contact depends upon the mobility of its structure. We say partial vacuum, because the process of mechanical exhaustion can never produce a perfect vacuum. If the water which gives softness to mucous tissues was perfectly free to move, the cavity would be instantly filled, however deep. Parts as mobile as the tongue and lips yield readily to this fluid pressure; but the mucous membrane of the alveolar ridge and palate, being more or less tied down to the bone, fills the cavity more slowly; if too deep it will not fill it at all, except by hypertrophy. Reverting to the experiment of the key: if violent suction is made a purple spot is left upon the lip; the mucous tissues being prevented by their structure from filling the vacuum, the fluids still feel the impulse of atmospheric pressure; the blood, thus impelled with a force which the thin capillary walls cannot resist, is extravasated, as takes place also in the application of "dry cups." Hence,

where a dental-plate cavity is so deep that the tissues cannot fill it, if the degree of exhaustion is such as still to draw upon the surface, the tissues are in danger of being ruptured. Such a source of irritation will in many persons develop morbid action and should forbid the use of deep cavities in any plate.

Secondly: The shape of the edge modifies the rapidity with which the cavity fills. If the edge of a cupping glass is rounded the skin glides under it and is drawn from the adjoining parts into the glass; but if the glass is ground so as to present a sharp edge on the inside, this beds itself in the surface and prevents so much of the adjacent skin from being drawn in. It rises to a less height in the cup, and the remaining force of the vacuum is spent upon the capillary vessels, which are ruptured. Hence we learn that sharp-edged cavities fill less rapidly, but act with more power upon the tissues; they are consequently more apt to excite disease if the cavity has sufficient depth to allow continued action.

Thirdly: As to the cause of the final dropping off of the key: water and all the moist tissues of the body contain atmospheric air which they yield up under a vacuum. Hence a mucous membrane, although at first drawn strongly into a cavity, will make the vacuum less complete by giving out of the air contained in its tissue and in the blood constantly circulating through it. The adhesion of a vacuum, therefore, over mucous membranes requires renewal by occasional suction, since the blood is constantly circulating through the surface and supplies air to the cavity. Mucous membranes have also the property of *absorbing* air, as is seen in the lining of the bronchial cells constantly and in the power of the mucous membrane of the intestines to absorb the gases there generated. This property acts an important part in absorbing small quantities of air unavoidably caught between the plate and the mouth; thus partly explaining the well-known fact that plates adhering by simple contact become tighter after being worn awhile.

Thus the double action of mucous membrane, absorbing minute portions of air pressed against it, and giving out its contained air to a vacuum, favors the retention of simple contact, whilst it acts against the efficacy of the vacuum. In either case it prevents the full force of pressure theoretically possible. The practical inference from the lesson of the key is that the Vacuum Cavity acts well at first, and may be useful for the temporary purpose of retaining a plate until the changes of which the mouth is capable adapt it more perfectly to the plate; but for permanent adhesion the only reliable application of the atmospheric-pressure principle is the Adhesion of Contact, which is fully developed only when the contact of the plate is complete. A vacuum

cavity, acting as such, gradually draws the gum into it and finally fills it by a more or less permanent enlargement; when thus filled the plate is retained solely by the adhesion of contact. When a cavity intended to hold up a plate leaves no prominence or mark in the mouth, it unmistakably proves that it is exerting no force; so far from aiding in the retention of the plate it diminishes the force of adhesion by the presence of air, and has no compensating advantage except in removing pressure from a hard palate membrane. There are, however, other and better ways of obtaining an air space, as elsewhere explained, without the presence of a cavity, which marks the failure of its original purpose.

ADHESION OF CONTACT.

Full plates, which are designed to adhere by force of contact, differ from those retained by spiral springs in that the former are larger than the latter, covering more of the palate, so as to give a larger surface for the pressure of the atmosphere. They may cover the whole of the outer surface of the alveolar ridge and a considerable portion of the roof of the mouth; but should not go as far back nor run so high up as some dentists are in the habit of extending them. If allowed to cover those parts of the bone where the cheek muscles on the outside of the ridge or the palate muscles at the back of mouth are inserted, the gums will be chafed or ulcerated, the patient nauseated, and the piece rendered unstable by the action of the muscle. It is not always necessary to employ a very wide plate to give secure retention, for a comparatively narrow one will often adhere with very great tenacity to the gums. But such a plate is more liable to be bent and lose its perfect adaptation to the parts than a wide one, unless made thicker in proportion as it is narrower. As it is never necessary to make an upper plate so narrow as a lower one, there can be no difficulty in giving the requisite strength, either by increasing the thickness throughout or by doubling the anterior half.

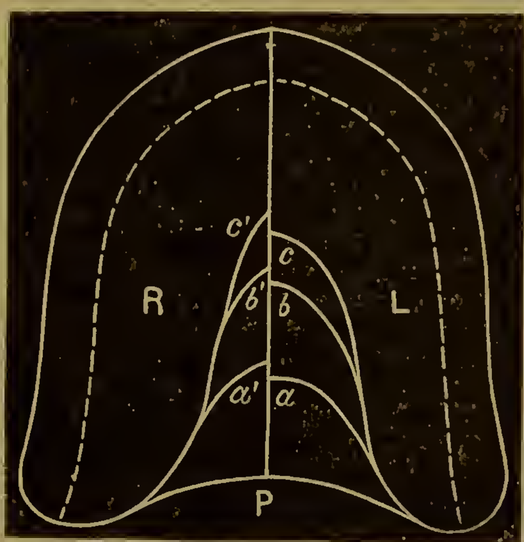

FIG. 1079.

The diagram (Fig. 1079) represents half-section outlines of six modifications of form in the posterior margin of the plate, where it is proposed to overcome the difficulties incident to a hard palatine membrane by cutting out the plate. The line P, curving forward from a

little behind the termination of the top of the ridge (dotted line), is the extreme limit of any plate not complicated with cleft palate. The curve *a* or *a′* will give surface sufficient for the retention of most plates, except in small arches. This form is more agreeable to the patient than the first, and is less apt to produce nausea; it removes the plate from all action of the palate muscles, and lessens the liability to dislodgment often caused by the forcible action of the tongue against the back of the palate in certain efforts of deglutition. The curve *b* or *b′* may often be used solely to avoid unnecessary covering of the palate. In mouths of average size and having moderate and regular softness such shape will prove quite as firm as one following the line P. But these lines are more frequently to be followed, for the same reason that we take the curve *c* or *c′* to keep the plate off the hard central ridge. When this ridge is narrow we give greatest width to the plate by following the curves on the side R of the diagram; but if the surface is broad the space must be widened, as on the side L, and the plate made thicker.

This method of relieving the central bearing of plates gives them great steadiness in the ridge, and has an advantage over other methods in having no band or ridge of plate pressing along the line P—a point very often as hard as any other part of the palate. It is advisable in those cases where a vacuum cavity has been tried with unsatisfactory results to cut out the cavity and part behind it, and thus try the effect of a plate following curve *b* or *c*.

There are other methods of taking off the central bearing of plates. When the ridge is soft a wax impression does this by compressing the gum. Models from plaster impressions are scraped on the ridge for the same purpose; but this is not so good a plan, as it is difficult to do it uniformly. A much better expedient is to brush some thin plaster over the central part of the model, being careful to mark the line of the back edge of the plate, and put no plaster there; this layer must not be thicker than a card, and should have no abrupt edges. A thin layer of wax may be added in the same manner to plaster models before molding in sand to obtain the die for swaged metal plates. In deep arches the shrinkage of the zinc die accomplishes the same object; if the model is carefully scraped along the back edge of the plate this part will fit closely, while the central portions will stand off; this is far better than the attempt to adjust the edge with pliers.

In adapting atmospheric-pressure plates the form and fit of the alveolar margin must be considered. Close adaptation of this edge is by no means so essential to firm retention of a full upper piece as in the posterior margin; for the reason that, in most cases, the loose mucous folds which lie against the plate prevent the access of air. But close-

ness of fit is very desirable for other reasons: to prevent lateral motion; to avoid unnecessary fullness; to prevent irritation of the soft parts by projecting edges of metal. The form of the alveolar edge is not essential to adhesion, provided it rises high enough to give steadiness to the plate. Esthetic considerations, however, often compel us to run the plates up as high as the muscular attachments will permit, either for the support of an artificial gum or to restore sunken features. In both jaws, especially the lower, the effort to get the deepest possible edge often gives instability by subjecting the piece to the action of the facial and lingual muscles. In any case of doubt make the plate too shallow rather than too deep; especially when the edge is turned over, which makes it impossible to take off any excess without spoiling the plate.

Full lower plates are held by adhesion of contact; but in these the weight of the piece increases the adhesion. The surface is so small that every part of such plates should fit the gum with accuracy. The simpler rule for the form of lower plates is to extend them as far on the inner and outer edges as the muscular attachments will permit. The outer and inner edges are often rounded by soldering a gold wire after determining the exact outline. Thickness of the edge is also given by doubling the plate necessary for the strength of narrow plates. The second plate is to be swaged precisely as the first; then, after partial trimming, the two plates are swaged together over a new die. One should be wider than the other on the outer or inner edge, to give a place for the solder; the borax cream should be free from granules, and the blowpipe flame directed on the edge opposite the solder. A simple and convenient clamp for binding plates together or holding rims while being soldered is made of iron (or nickel) wire (Fig. 1080). *a*, the first bend; *b*, the second bend; *c*, a side view of the same; *d*, side view of clamp, open and grasping two pieces of plate. The curves should be so adjusted that the points of contact with the plates will be just opposite, else clamp or plates are liable to change position.

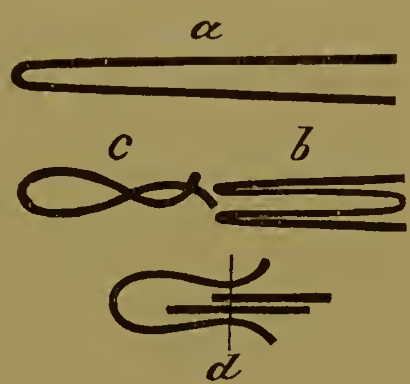

FIG. 1080.

Partial pieces may also be retained by closeness of adaptation; but there are two elements of instability which usually will prevent them from having the security of full sets or of partial clasp pieces—lateral movement and extent of margin, admitting air on slightest motion. All such pieces should, if possible, have two stays, one on each side of the mouth, to prevent lateral motion; they should cover an extent

of surface proportioned to the number of teeth; the edges of the plate should fit with great accuracy. If the exact outline of the plate is determined on, a good plan is to paint the model with a coat of thin plaster, keeping one-eighth inch inside the margin and laying an extra coating over very hard places; this causes the edge to sink slightly into the gum; yet if carefully done it will not change the general contour of the surface. Partial plates, holding the eight, ten, or twelve anterior teeth, if assisted by stays against the remaining molars, are nearly or quite as firm as full plates. But in either partial or full pieces, whenever the plate has to be cut off for setting the six front teeth directly on the gum, this dentated margin is more apt to admit air than the upturned rim, which has the folds of the lip lying against it. Partial lower plates are unstable, not from any admission of air, but because of the small extent of surface, inadequate to the pressure of mastication.

Plates for partial dentures to be held in place by clasps or bands are generally made narrow, and the posterior line or edge within the depression of the rugæ, so as to be out of the way of the tongue, but such plates must not be made too small, or they will cause pain by being forced into the mucous membrane. Partial lower plates for artificial bicuspids and molars, the six natural anterior teeth remaining in the mouth, should extend up on the lingual surfaces of the natural teeth to prevent the too great pressure of the plate against the inner surface of the alveolar ridge, and also to give greater strength by the increased width and form of the plate back of the natural teeth, which would otherwise have to be made very narrow and thick. The lower inner edge of full and partial lower plates should extend so far down as to be out of the way of the tongue. Carrying the edge of such a plate over the projecting surface of the ridge, which is generally present, into the receding underspace, will prevent the tip of the tongue from getting under it; at the same time the plate should not extend so far down as to interfere with the frenum of the tongue.

A tongue or catch may be swaged as part of a partial lower plate to extend slightly over the angle of the crown of a posterior natural tooth, such as a molar or bicuspid, and catch on the grinding surface, and thus prevent a partial lower denture from pressing painfully on the gum. This tongue or catch should be adapted to the grinding surface of the natural tooth at a point where it will not interfere to any great degree with the occlusion of the natural teeth. Partial stays fitting as far as possible into the interspaces between such natural front teeth as remain in the mouth, will prevent partial lower dentures containing artificial bicuspids and molars from sliding backward, as

all such dentures have a tendency to do. Such stays will also prevent the plate from being raised from its place by the cheeks and muscles.

THE VACUUM CAVITY.

In some mouths the base plate of a full upper piece adheres from the beginning with great firmness. When the gum is moderately and regularly soft, the palatine arch deep, and the mouth of average size, want of adherence, on trial of the plate, is positive evidence of defect in construction. But very hard or very small or very shallow mouths usually require time for the perfect adaptation of the best made plates. Dr. Dwinelle thus explains the temporary failure of a simple atmospheric pressure plate to fit firmly when first inserted. When the plate is applied and an effort made to exhaust the air the gums are drawn down so as to meet it along the line and behind the edge of the plate, thus resisting every effort made from without to withdraw the air from the central part of the plate; so that the pressure of the atmosphere is exerted upon only a small breadth of surface along its edge, where the adhesion is constantly liable to be disturbed in mastication.

With the view of obviating this difficulty the idea of constructing a plate with a cavity suggested itself to the author as early as 1835, and was mentioned at the time to several of his professional brethren. The construction of the chamber then devised was found objectionable and he abandoned its use; and it was not until the early part of 1848, when he had the opportunity of seeing a cavity plate upon a plan contrived by Dr. J. A. Cleaveland two or three years previously, that he was again induced to construct a base plate of this kind. Dr. Dwinelle made a cavity plate with an external opening and valve for exhausting the air in the winter of 1845; and in the summer of 1847 or 1848 Dr. Jahial Parmly exhibited to the author a plate with a simple cavity struck into it by swaging. Some months after he heard for the first time of a cavity plate patented by Mr. Gilbert, of New Haven. The cavity now generally employed is formed on the median line, either far back for full plates (Fig. 1081), or immediately behind the alveolar ridge for some partial plates. Dr. Flagg adds two lateral cavities on the slope of the palate with a view to prevent the plate from rocking and to give it increased stability. Dr. Levett's lateral cavities are placed directly upon the ridge (Fig. 1082). With this brief history of cavity plates we shall proceed to give a concise description of the manner of constructing them. The following is the mode of construction of Dr. Cleaveland's cavity plate, which, for reasons given below, is now seldom used.

A metallic die and counter-die having been obtained, a plate is

swaged, covering the entire alveolar border and extending back as far as the line P (Fig. 1080). This done, it is placed in the mouth, and if found to be accurately adapted to the parts it is removed; a half-round gold wire about the size of a common knitting needle is then soldered to the lingual side of the plate, enclosing a space shaped somewhat as is shown in Fig. 1081, varying in size and form with the differences in shape and size of the plate and alveolar ridge. The part within the wire is next cut out with punch-forceps or saw and the plate placed on the model; a piece of wax about a tenth or twelfth part of an inch in thickness, having a circumference one-fourth greater than the hole in the plate, is then placed over the opening, extending a short distance beyond the wire on every side. The wax at the outside is brought to a thin edge and is also made thinner in the center than where it covers the wire surrounding the opening in the plate. From this model with plate and wax upon it, die and counter-die are obtained with which to swage a thin plate of gold, large enough to cover the wax; its edge is chamfered off, and it is then

FIG. 1081.

FIG. 1082.

soldered to its place on the plate, where it may be secured during soldering either by iron wire clamps or by gold rivets. A sectional view of the cavity is represented in Fig. 1083 A. The Cleaveland cavity causes the plate to adhere with great tenacity, as from its shape it is impossible for the mucous membrane entirely to fill it; the traction of this cavity is constant. A serious objection to its use is the great irritation it excites in the mucous membrane in the majority of cases.

The simpler cavity plate used by Dr. Jahial Parmly, of New York, and patented by Mr. Gilbert, of New Haven, may be formed with nearly as much ease as a plain plate. Fig. 1083 B represents a sectional view of this description of plate. If it is desired to have lateral cavities, three pieces of wax or metallic forms are placed on the plaster model—one in the center, as already described, and one on the slope of the alveolar ridge on each side. When it is desirable to make a cavity with sharply defined border, D, a second plate a little larger

than the projection should be swaged over the base plate. From the base plate the projection is to be cut out and the smaller plate soldered over the opening. For hard mouths the thickness of the main plate will give sufficient depth of cavity, C; in this case no projection is to be placed on the model.

Should the usual method of exhausting air from these cavities be thought insufficient, the valve of Dr. Dwinelle (Fig. 1083 V) may be inserted in the plate covering the cavity. The conical portion is neatly fitted by grinding; the stem is soldered to a spring on the palatine surface. A valve of easier construction is given at V′; a small rubber pad acts, by the spring, upon the outside of the hole. The size of valves and thickness of plate are exaggerated, the better to illustrate the details of construction. By means of either of these valves a vacuum may be created, which will draw with great force upon the membrane over the cavity.

The forms B and D, Fig. 1083, necessitate a prominence in the

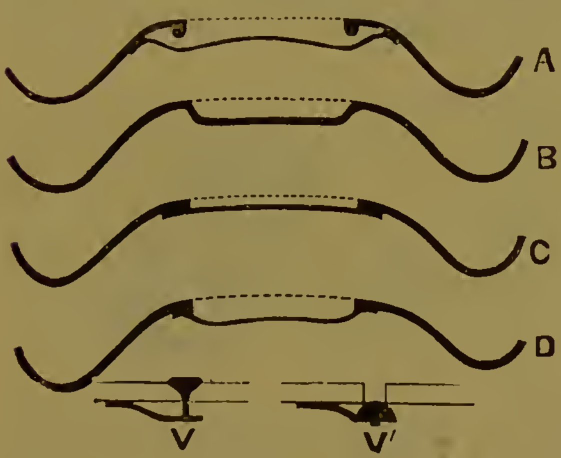

FIG. 1083.

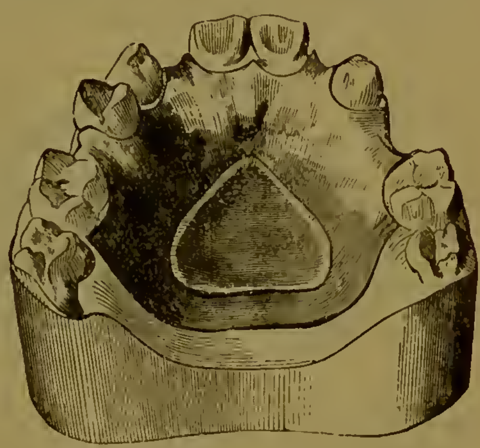
FIG. 1084.

die which is variously formed. When the die is made by sand molding, a corresponding one, formed of wax, lead, tin, or plaster, is put on the model; a die made by dipping or pouring or by the fusible metal process requires plaster. Dies made by pouring into the impression require the cavity to be cut in the impression itself. A variety of shapes in tin and alloy are furnished by the depots, chiefly for vulcanite work; but they may be used also for the sand molding model. Plates made by the metallo-plastic processes require plaster prominences.

The size, depth, form, and position of the cavity are important considerations. In size it must be proportioned to the plate. Fig. 1084 gives a fair average size and is excellent in form, except that it is unnecessarily pointed; all angles and sharp corners should be avoided, and fanciful shapes are esthetic blunders; the form should appear to

grow out of some necessity; and hence it should be modified to suit the form of plate. Shallow cavities may be larger than deep ones; partial pieces usually have a cavity larger in proportion.

Fig. 1085 represents the usual forms of vacuum cavities (the shield form being objectionable on account of its sharp angles), which may be metal, such as block tin, that will not discolor the rubber; vacuum cavities made of sheet lead are objectionable on that account.

In depth the cavity must vary with the softness of the membrane. If soft it quickly fills a shallow cavity and is less liable to injury by a deep one. Sharp-edged cavities fill less quickly than round-edged ones. They may vary in thickness from No. 14 to No. 24 gauge plate, page 826. When the cavity is designed, after a temporary retaining power, to act permanently in relieving the pressure on central hard parts, it should be very shallow. When, in very flat mouths, it is proposed to prevent lateral motion by the mucous prominence the cavity should be deeper. Extreme depth, with a view to keep up constant action, makes a most unsightly piece and injures the mouth.

When the center of the palate is very hard and unyielding, as is

FIG. 1085.

generally the case, and not subject to change of form by pressure, while the alveolar ridge and some other parts are subject to absorption, if the palate is permitted to rest on the hard central portion, the result will be its rocking. This may be prevented and good adhesion secured by covering the entire hard palate on the plaster model from near the anterior margin to within one-fourth of an inch (or in some cases even less) of the posterior margin of the plate, when to be of metal, with a thin film of wax (about one-half the thickness of a wax base sheet), with the edge all round reduced even with the surface of the model. In vulcanite plates or sets adhesion can be secured on the same principle, by removing, with a large cone bur in the lathe, the same amount from the palatal surface of the plate.

As to position there would seem to be much difference of opinion, if we judge by the various points selected. We have never had but one opinion on this subject, and that is in favor of the central cavity. The cavity resists the greatest force of displacement when applied at right angles; as this force is always nearly or quite vertical, it follows

that the most effective cavities are horizontal; hence they should only be on the roof of the palate and limited to its level portion. Cavities covering the rugæ or sloping walls of the palate act at disadvantage. Again, after the cavity ceases to act its secondary use in relieving pressure can be available only in this position. The very worst position for a cavity is on the ridge of either upper or lower jaw. Firm pressure on the ridge is one of the most important elements of stability in a plate. If is difficult to comprehend what compensation for the loss of this is found in the cavity.

Partial plates require, when the cavity is used, a modification of form to enable the cavity to be placed on the roof of the palate. Yet the shapes elsewhere given may be used in connection with Flagg's lateral cavities as represented by the oval in Fig. 1086. If no stays can be used, as in a piece of artificial bicuspids and molars with natural incisors and canines, a central or two lateral sharp edged cavities may be of service to prevent lateral motion. In all other partial cases stays may be used; these, combined with accurate fitting, will give as

FIG. 1086.

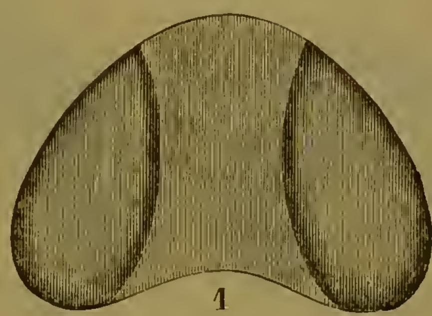

FIG. 1087.

firm a piece as any form of cavity. The vacuum cavity may also be formed in the impression by adapting a form of wax to the roof of the mouth in the proper position before inserting the tray.

Dr. C. H. Land has recently suggested a vacuum cavity pattern (Fig. 1087), which is claimed to be of such a form as to secure the greatest advantage from atmospheric pressure without injury to the mouth; also to serve as a relief to the hard portions of the arch by being of sufficient depth to allow for continued absorption of the alveolar ridge in the case of first sets; it is also claimed that its shape avoids interference with the organs of speech.

Dr. Joseph Spyer has devised an automatic suction cavity which, he claims, permits of the construction of a narrow plate with perfect adhesion.

Fig. 1088 is a view of Spyer's Suction Cavity as it comes ready for use. Fig. 1090 shows the Automatic Suction Cavity secured in position on the plaster model. Fig. 1089 gives a view of the palatal

surface of a finished plate, with metal form removed. While the Automatic Suction Cavity comes already shaped for the model, it is necessary to trim it down with curved scissors to meet the requirements of each particular case, always leaving a slight space between the slots or openings, A A, Fig. 1090, and the outer margin of the metal form. The Suction Cavity is then secured by means of pins, or by varnish or mucilage or any sticky substance, to the plaster model on the palatal surface inside of the alveolar ridge, leaving the alveolar ridge uncovered. A sharp instrument is then passed through the slots, A A, Fig. 1090, in the manner indicated in Fig. 1090, and carried their entire length, forming parallel grooves in the plaster model. Then the metal form is covered by the wax base plate, which should be the *size* of the finished plate, and in most cases approximating to the *form* of finished plate, shown in Fig. 1089. Upon the base plate the teeth are set up as usual, and the case flasked, packed, and vulcanized in the usual way. After vulcanizing, the metal form (the "Automatic Suction Cavity") *is removed.* If the parallel ridges are too high

FIG. 1088.

FIG. 1089.

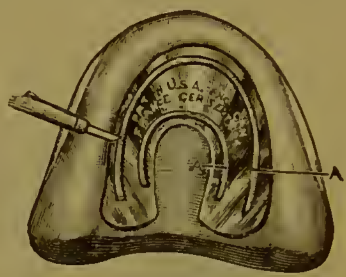

FIG. 1090.

after the plate is vulcanized, file them down to the desired height. The finished plate will have along the edge of its palatal surface two parallel ridges, as shown in Fig. 1089, besides the form of the suction, which provides strong adhesion from end to end of the plate.

Dr. Joseph Spyer has also devised for plastic work a thin metallic form, the surface of which is covered with minute papilliform prominences—shown in Fig. 1092 magnified four diameters—which by displacement of mucus at the points of gum contact effect surface cohesion as if the denture were glued to the gums, yet cause no irritation and leave no marked indentations. Adapted for either upper or lower plates. By the aid of this device it is claimed that strong cohesion can be had with a narrow plate, and thus the sense of taste be left unimpaired, and that lower plates so made are very firm. They are put up in packages containing one dozen forms size of Fig. 1091, which can be cut for either upper or lower plates. These forms are also made of gold with a thin covering of pure silver; the sulphur in

the rubber, when set free by the action of vulcanizing, sulphurizes the surface, and to this the rubber adheres.

Fig. 1093 represents Dr. Wünsche's metal adhesion form, which consists of a strong white metal plate, the material being hard enough to prevent the flattening of the convexities under any necessary pressure.

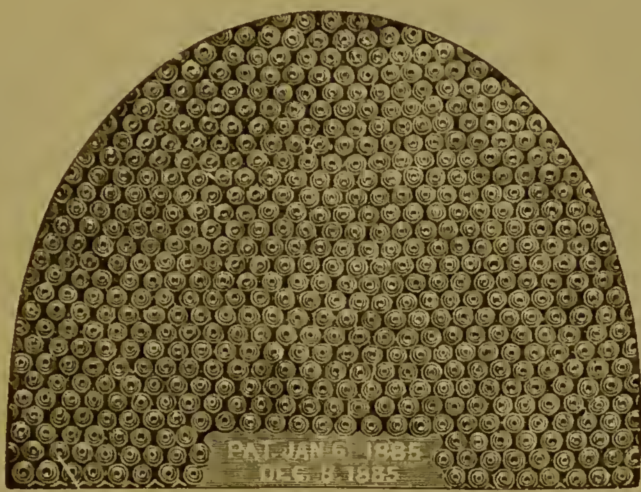

FIG. 1091.

SILVER PLATE AND SOLDER.—The processes heretofore described and the rules laid down have been considered mainly in their relation to artificial teeth mounted upon GOLD PLATE by the operation of soldering. But other metals may be swaged by the same processes, as platinum, aluminium, and silver.

Silver is the least valuable of these, and has nothing to recommend

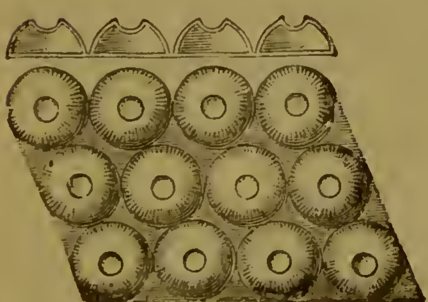

FIG. 1092.

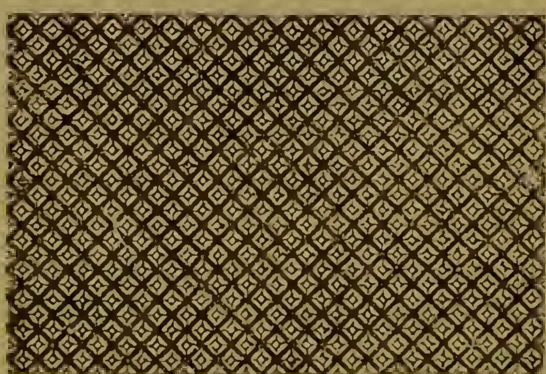

FIG. 1093.

it except its cheapness, in which questionable merit it has aluminium and vulcanite as its competitors, and hence it is now not very much used. It is manipulated in all respects like gold, except in the operations of refining by acids, the composition of solders used, and the care necessary in soldering, from the fusibility of the plate.

For plates pure silver alloyed with platinum possesses advantages

over coin silver, which oxidizes greatly in the mouth. The formula for such a plate is—

Pure silver,	1 ounce.
Platinum,	1 pennyweight.

Some prefer gold clasps for silver plates.

A good silver solder is composed of—

Pure silver,	6 parts.
Pure copper,	3 parts.
Pure zinc,	2 parts.

In the preparation of such a solder the silver and copper should be melted together and then the zinc added, pouring the molten mass into the ingot-mold before the zinc volatilizes.

Fine silver alloyed with one-third its weight of brass also gives a good silver solder, as the zinc in the brass reduces the fusing point of the alloy and makes it easy-flowing. If ½ to 1 grain of zinc is added to the above formula, the fusing point is still further reduced. After pouring the alloy into the form of an ingot, it should be rolled to No. 26 or 27, annealed, and its surface cleansed by placing it in the acid-bath.

Aluminium can be rolled into plate and swaged. It requires extreme care in annealing, but makes a rigid, strong, and very light plate. It does not withstand the buccal secretions as well as twenty-carat gold, nor is it as good as eighteen-carat gold. The obstacle to its general use also lies in the fact that as yet there is no good solder for it. Hence it is necessary to attach the teeth by vulcanite. This can be very successfully done, as vulcanized rubber adheres more closely to this metal than to any other, excepting, perhaps, pure gold or pure platinum. The process will be described in the section on Vulcanite; it is equally applicable to twenty-carat gold and to platinum, but not at all to silver. An alloy of aluminium which is cast directly upon the teeth is referred to under Metallo-plastic Work.

Platinum, if alloyed with five to ten per cent. of gold, has stiffness sufficient to be used as a base plate, in the manner previously given for gold. As it has no advantage over gold when used in this way its less cost is not a sufficient offset to the inconveniences attending its use and to the color, which is so objectionable to most persons that they are unwilling to pay as much as for the same work in gold. Platinum has, however, one remarkable property possessed by no other metal used by dentists except palladium, which is now scarcely at all, if ever, used; it cannot be fused in the highest heat of the forge or porcelain-baking furnace. Hence it is the only metal used for the metallic

pins and other fastenings inserted into porcelain teeth, requiring for its fusion the flame of the oxyhydrogen blowpipe. It is also the only metal used in a remarkably beautiful style of work known as the Continuous-Gum Work, which forms the subject of the next section.

CONTINUOUS-GUM WORK.

The idea of uniting porcelain teeth to a metallic base by means of a fusible silicious composition originated in France, where the method has to some extent been practiced since 1820. But Dr. Fitch, who spent much time in Paris and was well acquainted with the French method and Delabarre's formulæ, stated that the latter never perfected his recipes or brought them into practical use. The composition employed there, judging specimens, cannot be used in connection with porcelain teeth containing as large a proportion of feldspar as those manufactured in this country. Delabarre's compound, according to Dr. Locke, required 3761° Fahrenheit to fuse it completely. Below this it fused imperfectly and was found too fragile.

The process now known as the CONTINUOUS GUM consists essentially of a silicious paste, similar (except more fusible) in composition to that of which the teeth are made, which is applied around the bases and fastenings of teeth previously soldered upon a plate of purest platina, and then fused at a temperature of about 2200° Fahrenheit. It takes its name from the fact that, unlike blocks or single gum teeth, it presents an unbroken continuous gum outside the alveolar ridge, as is shown in Fig. 1094. It is applied in two layers—a yellowish-white *body*, giving the general contour of the gum, and an *enamel*, to produce that correct imitation of the natural gum for which nothing but ceramic materials have as yet been found suitable. Dr. Allen covered with the same material the entire lingual surface of the plate, and also certain projections outside of the molars and above the cuspids, designed by him for the restoration of the natural fullness of the face.

FIG. 1094.

This falling in of the features is due to the absorption of the alveolar ridge, and cannot be fully restored by an artificial set of teeth as usually made; since if the molars were set out to the original width of the teeth the force of mastication would fall outside the absorbed alveolus and render it practically useless. Dr. Allen's device corrects this sinking under the malar prominence of the superior maxilla and in the canine fossa, and thus greatly aids in the restoration of the face to its original appearance.

This process was patented by Dr. John Allen in 1851; but the priority of invention was contested by Dr. William H. Hunter in a suit, the progress and result of which were published in the dental periodicals of that period. Dr. Allen surrendered his patents of 1851, owing to certain defects in the same, and in 1856 a new patent was issued to him for the process as then improved. The process is very generally known as "Allen's Continuous Gum." The formulæ given in this chapter are those of Dr. Hunter, and the earlier ones of Dr. Allen. As all such materials are more perfectly prepared on a large scale, we think it much better to purchase than to make them.

A "continuous gum" piece made in the most perfect manner is only surpassed in point of beauty by the occasional productions of a very few block carvers; but so rare are these specimens of perfection in block work that we may safely say of the continuous-gum work that when properly made it is the most beautiful, as it certainly is the purest and sweetest, that can be worn in the mouth, so long as the porcelain covering maintains its integrity. It was thought when this method of mounting artificial teeth was first adopted that the springing of the plate in the act of mastication would cause the gum to crack and scale off, which did occur in a large proportion of the cases. Although the injury could be repaired by replacing the loss with fresh composition and fusing it to the fractured edges of the remaining portions and to the plate, yet this at one time formed a very serious objection to its use. But later improvements in the strength of the compound and also in the rigidity of the plate and soldered backings, or long pins, have so far corrected this evil that it is perhaps no more liable to accident while in the mouth than any other kind of work. But out of the mouth its weight renders it peculiarly exposed to accident; a fall is almost certain to break one or more teeth or crack the silicious covering of the plate. Hence it is necessary to impress upon the patient the great importance of the most careful handling.

By uniting the teeth to each other near their base and to the plate with a glazed porcelanic material, the cleanliness of the substitute is most perfectly secured; as all the openings beneath and around them are completely closed, excluding the secretions of the mouth and particles of food, which have no affinity for or action upon the porcelain. In this respect they are superior to the most perfectly mounted block-teeth, while the labor of putting up a set of the former can be performed in half the time required for making and mounting a set of the latter. A person who can mount single teeth well may acquire a knowledge of this method with proper instruction in a few weeks; although much of the peculiar talent required in block-carving is needed in arranging the teeth and shaping the gum for this process,

the details are comparatively simple and may soon be taught. Of course, much practice will be required, especially in the management of the furnace heats. The necessity for such practice, to enable one successfully to manage the furnace, is the chief obstacle to its casual use by the practitioner. Unless he makes it a specialty, and does all his own work and some for his neighbors, he will be certain to meet with many discouraging failures in the final process of baking an otherwise perfectly constructed piece.

We therefore advise the dentist to swage the platina plate, select and arrange and articulate the teeth; for no one should be so competent to do this as the one whose intercourse with the patient enables him to judge exactly what form, color, and arrangement of teeth are best suited to the case; and only he can decide upon the correctness of the fit of the plate. But when all this is done the piece should be securely packed and sent by express or mail to some experienced worker in the continuous-gum. The piece will be returned with the plate unchanged in shape, and the porcelain work executed in such style as can be reached only by constant practice and familiarity with the special details of this work.

The artificial gum consists, as we have stated, of two parts; the first is termed the *base* or *body*, as this constitutes the principal part of the cement, and is used for filling in between the teeth and building up the gum on the plate; the other is *gum enamel.* The materials employed by Dr. Hunter in the composition of his compounds are silex, fused spar, calcined borax, caustic potash, and asbestos. The silex and spar should be of the clearest and best quality, and ground very fine. The asbestos should be freed from talc and other foreign substances and reduced to a fine powder. He gives the following formulæ and directions:—

Flux.—Take of silex, 8 oz.; calcined borax, 4 oz.; caustic potash, 1 oz. The potash is first ground fine in a wedgewood mortar, and the other materials gradually added until they are thoroughly mixed. Line a Hessian crucible (as white as can be had) with pure kaolin, fill with the mass, and lute on a cover of a piece of fire-clay slab with the same. Expose to a clear, strong fire in a furnace with coke fuel for about half an hour, or until it is fused into a transparent glass, which should be clear and free from stain of any kind. This is broken and ground until it will pass a bolting sieve.

Granulated Body.—Spar, 3 oz.; silex, $1\frac{1}{2}$ oz.; kaolin, $\frac{1}{2}$ oz.; completely fused. Break and grind so that it will pass through a wire sieve No. 50, and again shift off the fine particles, which pass through No. 10 bolting cloth, which leaves it in grains about the size of the finest gunpowder. It may be made of hard porcelain, fine china, or Wedgwood ware.

Body.—Take flux, 1 oz.; asbestos, 1 oz.; grinding together very finely, completely intermixing. Add granulated body, $1\frac{1}{2}$ oz.; and mix with a spatula, to prevent grinding the granules of body any finer.

Enamels.—No. 1. Flux, 1 oz.; fused spar, 1 oz.; English rose red, 40 grains. Grind English rose red extremely fine in a mortar, and gradually add the flux and then the fused spar, grinding until the ingredients are thoroughly incorporated. Cut down a large Hessian crucible, so that it will slide into the muffle of a furnace, line with a mixture of equal parts silex and kaolin, put in the material, and raise the heat to the point of *vitrification*, not *fusion*, then withdraw from the muffle. The result will be a red cake of enamel which will easily leave the crucible, which, after removing any adhering kaolin, is to be broken down and ground tolerably fine. It may now be tested, and if of too strong a color tempered by the addition of *covering*. This is the gum which flows at the lowest heat, and is never used before soldering.

No. 2. Flux, 1 oz.; fused spar, 2 oz.; English rose red, 60 grains. Treat the same as No. 1. This is a gum intermediate and is used upon platina plates.

No. 3. Flux, 1 oz.; fused spar, 3 oz.; English rose red, 80 grains. Treat as the above. This gum is used in making pieces intended to be soldered on, either in full arches or in the sections known as *block work*. It is not necessary to grind very fine in preparing the above formulæ.

Covering.—What is termed covering is made by the same formulæ as for the enamel, omitting the English rose red. Being without any coloring whatever, it is used for tempering the above enamels when too highly colored, which may be done by adding, according to circumstances, from one to six parts of covering to two of enamel, thus procuring the desired shade. When it is to be used for covering the base prior to applying the enamel it may be covered with titanium, using from two to five grains to the ounce.

Investment.—Take two measures of white quartz sand, mix with one measure of plaster-of-Paris, using just enough water to make the mass plastic, and apply quickly. The slab on which the piece is set should be saturated with water to keep the material from setting too soon, and that it may unite with it.

Memoranda.—In preparing material always grind dry and use the most scrupulous cleanliness in all the manipulations. In all cases where heat is applied, it should be raised gradually from the bottom of the muffle, and never run into a heat. Where it is desired to lengthen any of the teeth, or to mend a broken tooth, it may be done with *covering*, properly covered with platina, cobalt, or titanium.

In repairing a piece of work wash it with great care, using a stiff brush and pulverized pumice stone. Bake over a slow fire to expel all moisture and wash again, when it will be ready for any new application of the enamel. Absorption occurring after a case has been some time worn, by allowing the jaws to close nearer causes the lower jaw to come forward and drive the upper set out of the mouth. By putting the *covering* on the grinding surfaces of the back teeth in sufficient quantity to make up the desired length, this difficulty may be to some extent remedied.

Any alloy containing copper or silver should not be used for solder or plate, if it is intended to fuse a gum over the lingual side of the teeth, as it will surely stain the gum. Simple platinum backs alone do not possess the requisite stiffness, and should always be covered—on platinum with the enamel, and on gold with another gold back. In backing the teeth lap the backs or neatly join them up as far as the lower pin in the tooth, and higher if admissible, and in soldering be sure to have the joint so made *perfectly soldered.*

The compositions originally employed by Dr. Allen consist of—Body: Silex, 2 oz.; flint glass, 1 oz.; borax, 1 oz.; wedgewood ware, 1½ oz.; asbestos, 2 drams; feldspar, 2 drams; kaolin, 1 dram. Enamel: Feldspar, ½ oz.; white glass, 1 oz.; oxid of gold, 1½ grains. Since the publication of the early editions of this work great improvements have been made in the composition and preparation of both the body and gum enamel, which are furnished by the manufacturers, and may be obtained at any of the dental depots at a very moderate price.

The metals which may be employed for the base in this method of mounting artificial teeth are platinum or pure palladium. The common commercial article of palladium is not pure, and is never used in this country. Platinum, alloyed with from 1 to 10 per cent. of pure gold, may also be used; but it is objectionable from its liability to spring or warp. It makes a stiffer plate, and so far has the advantage over pure platinum, but for the reason given the purest metal should be selected. Because of its softness it must be used thicker than gold plate. The process of swaging the plate is the same as before given. It must be often annealed and gradually carried into any deep depressions, for its softness makes it more liable than gold to be torn, made thin, or punched through. A narrow rim, partially turned up, is to be left around the outside. The process of articulating, etc., is similar to that for gold. In adjusting the teeth accurate grinding is unnecessary; but each tooth should *touch* the plate. Part of each backing, where the teeth are lined, should lap over the adjoining ones, and behind the six front teeth should also be lapped over an additional narrow band,

to give greater rigidity to the plate. Continuous gum teeth with long pins are now used, the ends of the pins being bent down to the plate, to which they are soldered with pure gold; hence backing the teeth is not necessary. In this process there is great opportunity to give to the teeth that irregularity of arrangement which forms one of the characteristics of natural teeth, neglect of which gives to many otherwise excellent pieces of work an unnatural, artificial appearance, that shows great deficiency in the cultivation of dental *esthetics*.

Before applying the *body* the piece may be tried in the mouth and any inaccuracy of articulation readily corrected; careful articulation makes this trial unnecessary; but if from any causes changes are found on trial to be needed, they can be made more readily in this work before the gum is added than in any other; since no joints or neat fitting to the plate are disturbed by changes in the position of a tooth. After this the piece should be set in a mixture of plaster and asbestos or plaster and sand, resting on a muffle slide and coming up around the outside of the teeth to keep them in place. The solder used must contain no trace of either silver or copper, as such metals will stain the gum enamel and body, but must be either pure gold or alloyed with about 5 per cent. platina. Borax may be used, not in this case as a flux—for where there is no oxidation no flux is required—but to hold the pieces of solder in place until ready to flow. The slide is then gradually carried in to the muffle, and the whole piece raised to the melting point of the solder.

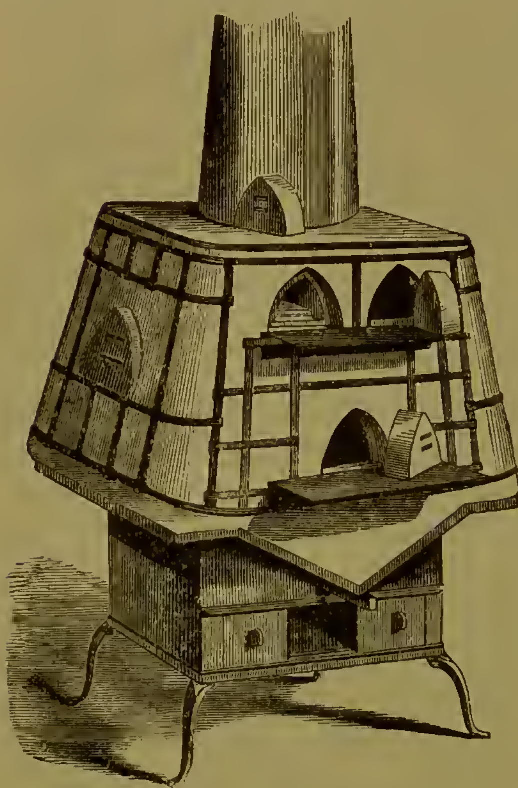

Fig. 1095.

Figs. 1095, 1096, and 1097 represent three of the most approved forms of furnaces.

The Combination Gas and Gasoline Furnace of Dr. Land is represented by Fig. 1096, in which is shown this furnace thrown open, being swung on hinges at the back, exposing the muffle E. The groove P P is packed with asbestos fibre, so that when the sections are brought together the furnace will be perfectly air and gas tight. It is claimed that with gasoline gas porcelain teeth can be enameled

in from ten to fifteen minutes, with ordinary illuminating gas in from fifteen to twenty minutes, according to quality.

Fig. 1097 represents Downie's Continuous Gum Furnace, in which it is claimed that a full case can be baked in from fifteen to twenty-five minutes.

The tempering ovens are on each side of the opening into the muffle,

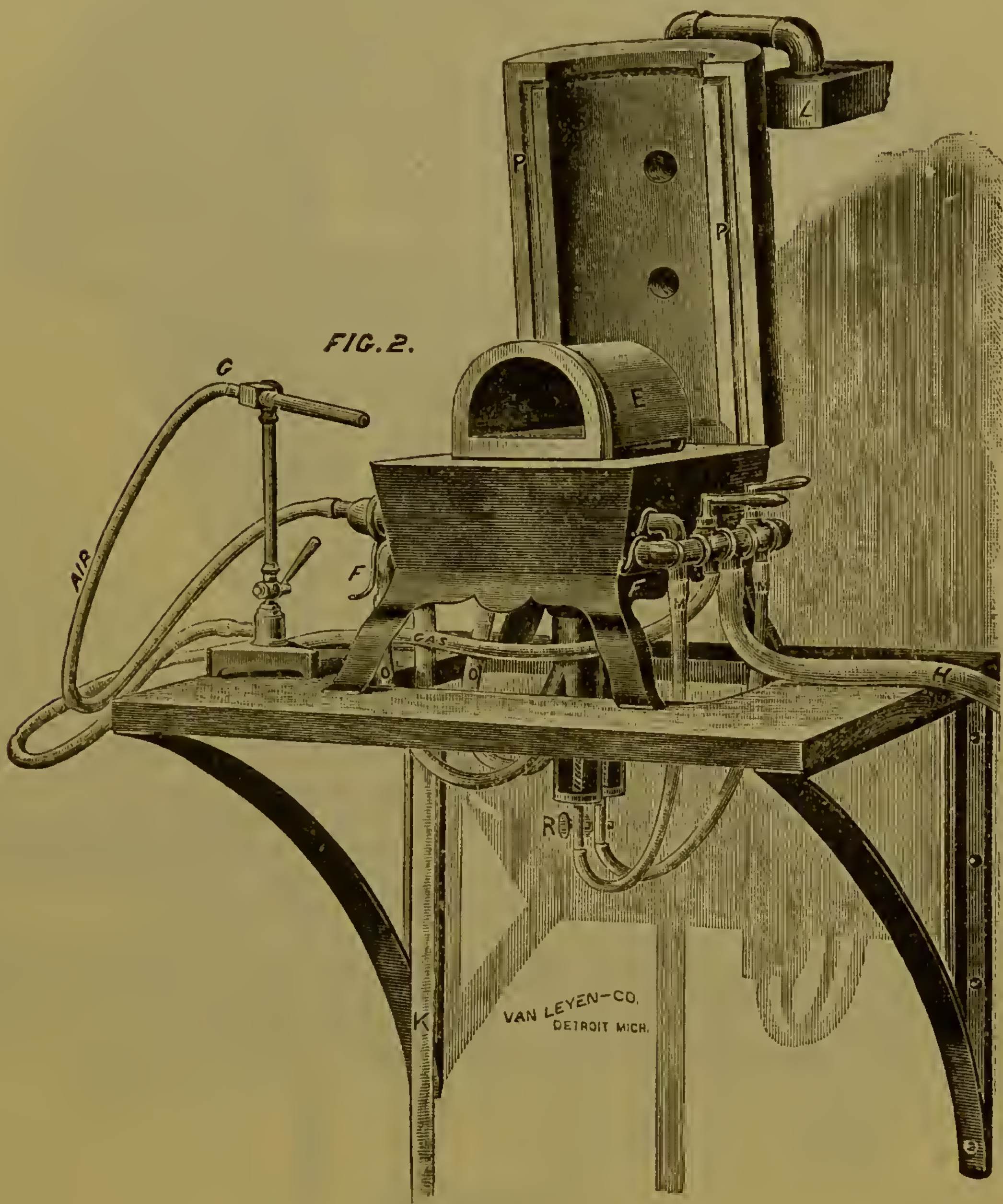

FIG. 1096.

and the hearth is provided with two sides, so the case can be brought out on to the hearth and put into the tempering oven by simply shoving the slide to one side by the small porcelain knob seen at the bottom of the hearth.

The rules for the management of the heat are the same as hereafter given for block work. The heat required for this is not, however, so

great as that required in block work; the gold and the continuous-gum materials fusing at about 2200° Fahrenheit.

Having thus soldered and cooled off the piece very gradually, it

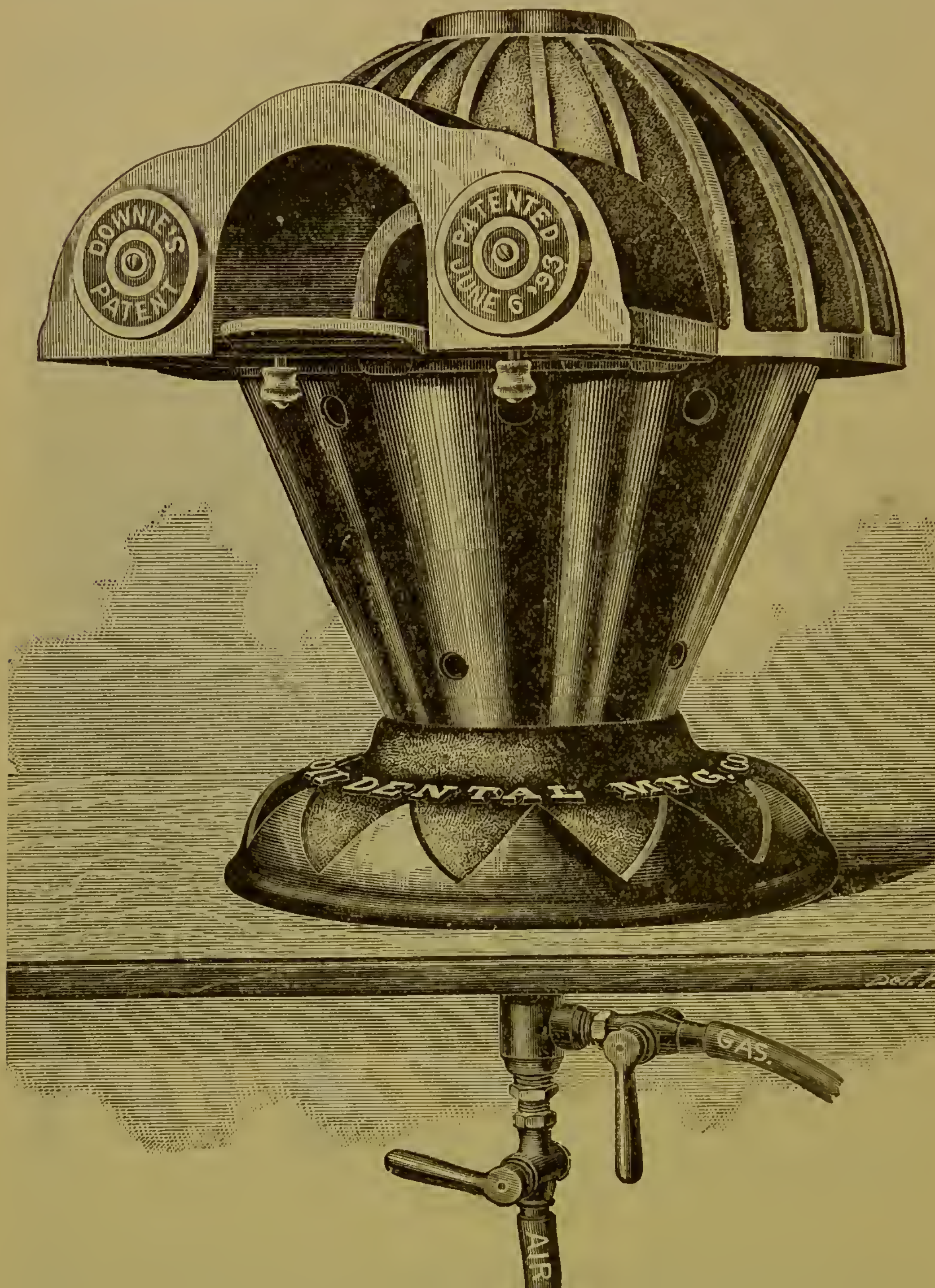

FIG. 1097.

must be thoroughly washed, so as to remove every particle of investment. Then, with a camel's-hair brush and small knife, such as are used in block carving, the spaces between the teeth and plate are to

be perfectly filled with a finely compacted paste of *body* and rain water. The paste must be applied very moist, so as to exclude the air and run into all the spaces; then dried with cloth or bibulous paper and compressed with the knife. If the lingual surface of the plate is to be covered, this should be made rough by either etching the surface or by soldering small clippings of platina over it at the time the teeth are soldered. The natural rugæ of the palate should be imitated in the thin layer of body which is applied.

The work must then be slowly and thoroughly dried and the piece put on a slide with the coronal ends of the teeth downward, and imbedded to the depth of an eighth of an inch in a thick batter of plaster and asbestos. But if the teeth are very securely soldered it will be best to flow the body with the plate resting, teeth upward, on the plaster and asbestos or sand model on which the soldering was done. The slide is then gradually introduced into the muffle and subjected to a heat sufficiently high to fuse the compound—say twenty-two hundred and fifty degrees. It is then withdrawn slowly and completely cooled. Usually there will be cracks and flaws which need filling with paste. The outside rim is also to be turned down over the edge of the body with hammer and pliers, and any defects at this point filled up; then heat a second time with the same care as at first.

The piece, now ready for enameling, should present a semi-vitrified appearance; if too highly glazed it is too much done, and the enamel will not take so firm a hold; if too dull looking it is not sufficiently baked, and will be deficient in strength. The enamel must be applied moist, and is best put on with a brush; much plastering with a knife makes it apt to fly off in baking, and for the same reason it must be heated *very* gradually. The layer of enamel should be thin and irregular, the yellowish white of the body showing more or less through it, so as to give the variations of tint observed in the natural gum. If a thick and even layer is applied the result will be an unnatural uniform color, which will destroy much of the peculiar beauty of this work.

The greatest care is necessary in applying the paste to remove every particle from the parts of the teeth and plate which are not to be covered, as it adheres with great tenacity and roughness, and disfigures these parts. Much experience is also necessary in determining the exact heat necessary to develop the full beauty and strength of the work. Repeated heatings, either for the first making or for repairs, do not injure the plate or teeth, provided proper care is taken to heat and cool gradually; and provided, in case of repair, the piece is thoroughly cleansed in strong soda to remove all trace of the buccal secretions.

The work is peculiarly adapted to full lower dentures. The principles of construction are precisely the same, only the plate should be very heavy, and the extra band behind the six or eight front teeth very thick and strong. Many use it for partial cases; for which, however, it is not as well suited as for entire dentures. The three distinguishing advantages of the continuous-gum work are its ready adaptability to every variety in shape of gum and arrangement of teeth, its extreme beauty, and its great cleanliness; its three disadvantages are its weight, its liability to be broken by accident, and its comparative inapplicability to partial cases.

CHAPTER XIV.

MOLDED PLATES OF PLASTIC MATERIALS.

In the classification of operations for the Replacement of Teeth given on pages 655 and 656, difference in the order of these operations was made the groundwork of a division of all BASE PLATES into two classes: SWAGED and PLASTIC. In describing, up to the point of completion of the model, the operations common to both classes, the modifying requirements of each were duly considered. The special order and details of swaged work were then taken up, with incidental allusions to plastic work, by way of comparison or contrast. Operations, materials, and apparatus peculiar to the latter will form the subjects of this and succeeding chapters.

PLASTIC WORK includes all dental substitutes in which the base plate is brought into contact with the teeth and the model of parts to be fitted whilst in a fluid, softened, or plastic condition, then hardened, during continuance of this contact, either by the application or the withdrawal of heat. Plasticity, as thus used, is the property of being molded, and has already been spoken of as an essential quality of impression materials. In them it is associated with other qualities especially fitting them for this particular use; so in plastic work mere plasticity is of no avail, if other properties do not give to the material the qualities essential to a base plate. It must have strength and durability, and must be in harmony with the parts to which it is applied. This harmony implies that it shall not act injuriously upon the mouth or receive injury from it; that it shall not, in form, color, taste, or smell, be repulsive to patients. It ought not, if possible, to be even objectionable; but tastes are so variable that this contingency

cannot be a positive ground for exclusion of an otherwise valuable material.

As in swaged work there are four metals of which plates may be formed—gold, platinum, aluminium, and silver—in plastic work there are five varieties of plastic material of which plates may be molded: 1, Porcelain clay; 2, tin and its alloys; 3, sulphurated gum; 4, celluloid and modifications; 5, aluminium and its alloys; 6, electro-metallic. The first two have been longest in use; the third and fourth have become the most important in modern dentistry; the fifth and latest has yet to pass the ordeal of experience. The *first* is molded by tools, not in flasks, as are the other four; it also requires intense heat to vitrify or harden it. The *second* is made plastic by fusion, requiring a flask, hot, to prevent cracking of teeth, and tight, to prevent escape of metal; these plates harden by cold. The *third* and *fourth*, less plastic, demand force in the act of molding; they are hardened by heat; but the temperature to which the teeth are subjected is less than in the other three. The *fifth* is made plastic by fusion; but, though more plastic than the third, in its pure state it does not flow as readily as the second; its extreme lightness and sluggish flow necessitate peculiar apparatus in molding; but some of these disadvantages have been overcome by alloying it with other metals. The *sixth* is a process by which gold and silver are deposited upon the surface of the plaster model prepared for the purpose.

Comparing them in respect of certain other properties—weight, durability, strength, and necessary thickness of plate; amount of change in shape, from contraction; resistance to change by the action of the buccal fluids—vulcanite and celluloid are lightest; aluminium being thinner, is very nearly as light; porcelain, though a light substance, requires such bulk that it is heavier than either; tin and its alloys are heaviest. Vulcanite plates, properly made, are strong, durable, and may be as thin as any, except aluminium; aluminium plates are thinnest and strongest; the durability of pure aluminium plates is still an open question; tin alloys are variable, some being tough and strong, others stiff and brittle, others soft and flexible; they have about the same bulk as gum, and the best are perhaps nearly or quite as durable. Porcelain plates contract very much; aluminium much less, but still very considerably; tin alloys contract very slightly; gum has no contraction. Porcelain most perfectly resists the buccal secretions and substances taken into the mouth; vulcanite nearly or quite as effectually; tin alloys undergo some change; aluminium is not changed by sulphur, as silver is, but will probably be found, in some mouths, to undergo slight change.

To give uniformity to nomenclature, the four varieties of plastic

work will be classed under four heads. 1. Ceramo-plastic, or porcelain. 2. Metallo-plastic, including tin, cheoplastic metal, other tin alloys, aluminium, and gold alloy. 3. Vulcano-plastic, including caoutchouc, gutta-percha, and all vegetable substances that by combination with sulphur, iodin, etc., have the property of hardening by heat under the process known as "vulcanizing." 4. Celluloid and its modification, zylonite, which are molded by heat.

CERAMO-PLASTIC WORK.

Porcelain plates are remarkable for cleanliness, and in the hands of a skillful worker in the ceramic art may have great artistic beauty. There are, however, several considerations that must prevent their extensive use. Like continuous-gum work, ceramic plates are best adapted to full sets. They are frail, occasionally breaking under the force of powerful mastication; they will inevitably break, falling on any very hard surface. It is but just, however, to state that the few who make porcelain plates a specialty claim that they are no more liable to accident than other pieces; that the teeth of all, especially continuous-gum, are as apt to break as this work; and that a broken tooth or plate is more easily and quickly mended in porcelain-plate work than in any other.

A second objection is the great shrinkage of any strong porcelain substance. Efforts to correct in the material itself this shrinkage make it proportionately weak. Correction by enlargement of the model is not only troublesome, but it is uncertain; the same is true of the correction by grinding with corundum wheels, which is very tedious and cannot be exact. When base plates were made of ivory and fitted to the mouth by carving, this imperfection of porcelain plates was not objected to because the former fitted no better, if as well; but in contrast with the exact adaptation of other forms of plastic work and of swaged plates it becomes very manifest. There are many mouths in which a porcelain plate could not be retained at all; there are others which adapt themselves so readily to moderate inaccuracies that such a plate is worn with entire satisfaction.

A third objection is the necessity of constant practice to keep up that skill in ceramic art which is essential to an artistic piece, and to insure uniformity of result by proper control of the furnace. This difficulty, however, can be met in the same way as in continuous-gum work. If the dentist will make the model, select and articulate the teeth, arrange them on a temporary plate with wax to give the fullness of gum, and a sample tooth to show its color, then pack securely and send to any block carver or porcelain teeth manufacturer, he can have a porcelain plate made better and with more certainty than only an

occasional practice will enable him to do for himself. If it is desired that the teeth and plate shall be carved at the same time, it will be sufficient to send correct model and articulation, with directions as to the style, color, etc., of the teeth. We think, however, that it will be safer for the dentist to select and arrange the teeth, as he can better judge what is appropriate than one who does not see the patient.

For details of construction the reader is referred to other chapters. Impression and model are made like any other work; articulating processes are the same as for other forms of plastic work; grinding the teeth is very simple, as in continuous-gum work; enlargement of the "furnace model" and manipulation of the porcelain mixture will be described in the chapter on Porcelain.

CHAPTER XV.

METALLO-PLASTIC WORK.

The use of a fusible metal in the construction of base plates is by no means new; but many of the metallic compounds suggested or now used for this purpose are of quite recent introduction. Except aluminium, none of them fuse above the melting point of tin, 442°. Pure tin is the oldest form of metallo-plastic base plate, and was used exclusively for the lower jaw. It is objectionable on account of its softness; even in a heavy lower rim it is apt to bend, and for an upper plate it is wholly unsuited. In its resistance to chemical change in the mouth it stands next to gold and platinum; is superior to silver and probably to pure aluminium; superior also, in this respect, to any of its own alloys. The process of constructing a lower plate of pure tin is the same as for any of the tin alloys.

Tin may be made harder and more rigid by alloying with Gold, Silver, Copper, Antimony, Zinc, Lead, Bismuth, or Cadmium. Copper and lead make it unfit for the mouth; antimony, zinc, and bismuth make it brittle, unless used in very moderate proportion. Silver gives it hardness, also cadmium, without imparting the objectionable properties named. Probably the best of all alloys for tin is cadmium. Closely resembling tin in its physical properties, it hardens it without making it too brittle or imparting increased liability to the action of fluids of the mouth. The majority of tin alloys at present recommended for base plates contain cadmium, with some zinc, antimony, or bismuth; they ought not to contain copper or lead.

Cheoplastic, Wood's, Weston's, and Watt's Metals.—The Cheoplastic Metal was patented by Dr. A. A. Blandy in 1856, together with certain processes used in the construction of dental plates. The manipulations since so familiar in the working of vulcanite were then as unknown as vulcanite itself. The peculiar merits of plastic work were at once recognized by many of the profession, and the Cheoplastic process would have passed into very general use, with such modifications as experience may have dictated, had it not been for the introduction of Hard Rubber. After some years' contest the profession decided in favor of rubber. Dr. Blandy's departure from the States in 1862 and the failure of the supply of his metal led to a total disuse of the cheoplastic metal.

The abuses of vulcanite and the gross mismanagement of rubber patents during their continuance urged many advocates of plastic work to revert to various tin alloys which are, in their principle of composition and in the essential character of the processes employed, identical with Dr. Blandy's patents. The name chosen by him (signifying the making of plates by *pouring* a metal made *plastic* by heat) is equally applicable to all alloys of tin now used. The alloy of the cheoplastic metal was silver with some bismuth and a trace of antimony. The exact proportions are not known, but may be learned by reference to the patents. The alloy imparted no taste whatever to the mouth ; and its purity, so far as its capability of resisting the action of the secretions of the buccal cavity is concerned, was said to be equal to eighteen-carat gold. Its color became slightly darker after being worn some weeks, but could be restored by placing it in a strong solution of caustic potash.

The cheoplastic metal was the pioneer of the numerous alloys of tin (stannum) which are now claiming the attention of the profession. We have elsewhere spoken of the necessity of testing all such alloys in the crucible of "practice." We shall mention those of Drs. B. Wood, H. Weston, and George Watt,—the first because next to the cheoplastic metal it has been longest known to the profession, particularly those alloys adapted to the filling of teeth ; the last because they are very strong, flow well, and retain their color well. The formula of Watt's metal is given as "tin, 40 dwt. ; silver, 8 dwt. ; bismuth, 16 grains."

Of the composition of Dr. Weston's alloy we know nothing beyond an assurance that it contains no copper, antimony, zinc, or lead. It may be better than any of its competitors closely resembling it ; but, in ignorance of the formulæ of any of them, we can only say what, perhaps, if we knew these formulæ we might still say—submit to the test of experience that which seems to be the best. Dr. Wood's alloys

are the result of an elaborate series of very careful experiments made some ten years ago. His plate alloys consist mainly, perhaps altogether, of tin and cadmium; they vary in fusibility, hardness, and rigidity, but are nearly, if not all, more fusible than Weston's metal. Dr. Watt's metal is said to withstand the chemical action within the mouth as well, if not better, than 18-carat gold, and to be strong and to run sharp. Molds may be made in almost any flask, but a special flask known as Watt's molding flask (Fig. 1098) is better adapted to the use of this metal than the ordinary flask. The following instructions, in connection with what remain to be given for vulcanite, will be a sufficient guide in the construction of plates made of Wood's, Weston's, Watt's, or any other stannic alloy.

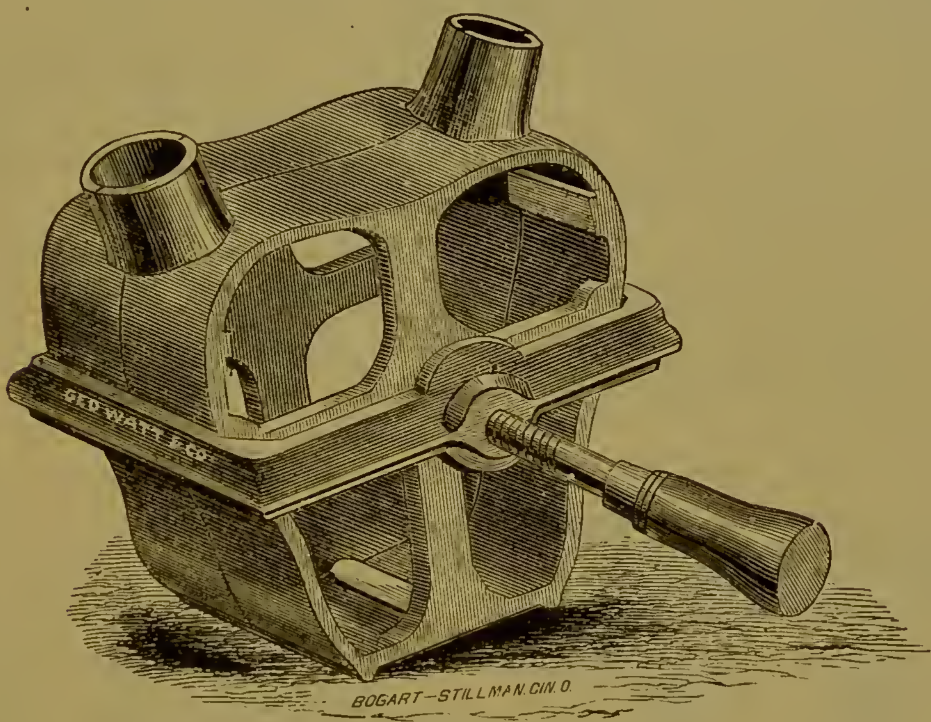

FIG. 1098.

Teeth for rubber work are best suited for this with the following precautions: First: Grind off the thin upper edge of gum teeth or sections; the anterior band is useful in rubber and does no harm; if of metal it is apt to crack the block and is unnecessary, as teeth are rather more firmly set in metal than in rubber; hence no metal should overlap the upper edge of the gum. Secondly: In jointing blocks do it as squarely as possible; if merely the edges of gums touch, the slight contraction of the alloy may cause them to scale or break. If, however, from accident or necessity this last kind of joint occurs, do as in soldering blocks to gold plate—place a thin piece of paper in the joint before securing it to the wax plate. Before drying the flasks this slight space caused by the paper may be closed with plaster and soluble

glass, to prevent metal from running in and making a metallic seam on the front of the block. Thirdly: Be careful to cover the pins with the wax which gives shape to the metal, so that in finishing up the latter they will not be exposed.

The Weston's improved flask consists of two rims without top or bottom, to permit rapid escape of moisture. It is much larger than the ordinary flasks, so as to allow room for the gate and reservoir posterior to the plate. It closes with two small bolts with nuts, and stands on feet. It is very important to screw the flask up well before pouring, that the weight of fluid metal may not separate the halves of the flask; the slightest space will allow much or all the metal to flow out.

The plaster may be mixed with soapstone powder, pumice powder, or clean white sand. Asbestos would prevent shrinkage, but its fibres would interfere with the free flowing of the batter. The same care in heating the flask is necessary as before stated, remembering that plaster confined in metal flasks takes longer to become dry. It is not safe to pour under less than three hours' drying; and this must never be done in direct contact with flame. Moisture is one of the products of combustion in all flame, and is largely absorbed by the plaster; hence plaster over flame can never be made perfectly dry, unless contained in some box, say of sheet iron, excluding this vapor.

Directions for heating, pouring, cooling off, and finishing are as follows:—

All necessary trimming of the plaster is done before the wax is removed, to prevent small pieces from falling in the matrix by the sides of the teeth. All of the wax is now removed, as the absorption of any considerable portions left in the matrix has a tendency to roughen the surface, and thus to prevent the metal from running as smoothly as it would otherwise do. After removing the wax each half of the matrix may be held over the flame of a tallow candle until a slight coating of lampblack forms on it. The two parts are now screwed firmly together.

The flask may now be placed in a kitchen range or bake oven and exposed to a bread-baking heat, say from 300° to 400° Fahr., for from three to five hours, or until every particle of moisture is driven from it; then placed in an upright position and the melted metal poured quickly into the matrix. If there is no ebullition and the metal comes up into the vents freely, the piece will come from the matrix in a perfect condition. If it bubbles it may be lightly tapped several times on some hard surface. When perfectly cold the two parts of the matrix are separated, exposing one of the surfaces of the plate.

Dr. A. Allen describes the method of using Watt's metal as follows:—

"The method of constructing a case is the same as for any of the

fusible alloys, or as follows: After securing the impression in the usual manner, give it a thin coat of shellac, then a thin coat of sandarac varnish; after the varnish is dry, soak in water and pour model without oiling impression, using a mixture of two parts plaster and one part Spanish whiting, or a mixture of two parts of plaster and one of finely ground asbestos.

FIG. 1099.

"The plate may be cast directly on to the teeth, or the base plate may be cast and the teeth attached in the usual manner of making rubber attachments.

"Teeth intended for rubber are most suitable for this work. If gum sections are used, grind square joints and slip a strip of writing paper into each joint while waxing up, removing just before flasking.

"If simply a base plate is to be cast, a piece of ordinary base plate wax is carefully molded over the model and trimmed to the gum line and dovetailed lugs added to secure the rubber (Fig. 1099). A rim with an under-cut edge may also be added if desired (Figs. 1100

FIG. 1100.

FIG. 1101.

and 1101). If for upper case the base plate should be of much thinner wax (Fig. 1100).

"If the case is to be cast directly on to the teeth, set them up as an ordinary case for rubber, using care to make the base plate smooth and just as you want the plate to be when finished. This will save much time in finishing. Invest the case in the half of the flask having

the guide pins, leaving only the base plate or base plate and teeth exposed (Fig. 1101).

"For the investment, use plaster three parts, and pulverized pumice stone one part. After hardening, trim carefully, and cut a groove from each heel to the pouring gates, dust the surface with powdered soapstone, then add other half of flask, and bolt; place pledgets of cotton in the pouring gates and fill, being careful to avoid air bubbles.

"When the investment has hardened, warm slightly, not enough to melt the wax, separate and carefully remove the wax. Cut grooves at

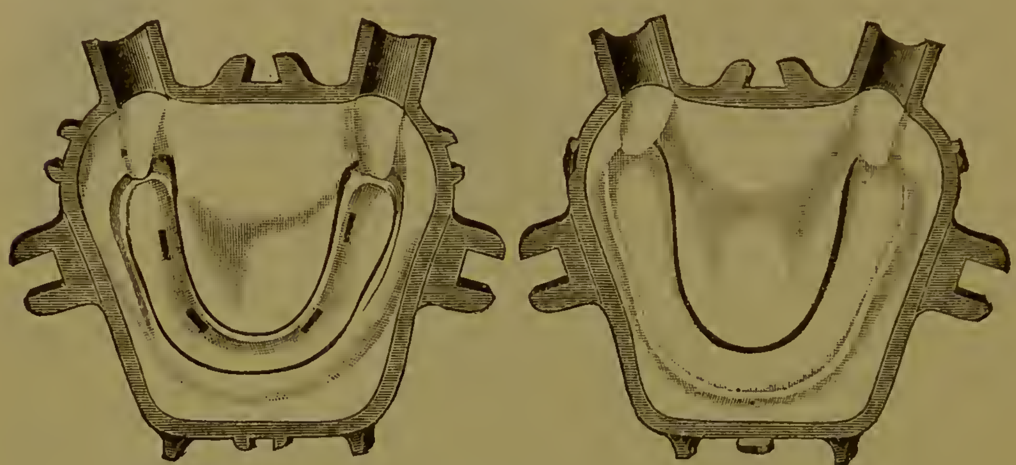

FIG. 1102.

heel corresponding with grooves in lower half, indicated by projections made by lower grooves (Fig. 1102).

"Place parts of flask together and carefully dry in oven or otherwise until moisture will not condense on a cold mirror placed over the vents.

"While the flask is still warm, melt an ingot of the metal in the ladle without stirring or shaking it. Do not heat the metal very hot. Simply watch the ingot until it is entirely melted and pour in a gentle, steady stream, stopping the instant it appears in the other opening. Do not jar or handle the flask until it has cooled, and use the melting ladle for nothing else.

FIG. 1103.

"It is a good plan to pack molding sand around the flask, or lute the joint with moistened kaolin just before pouring, to prevent the possibility of the metal escaping between the two parts of the flask.

"When nearly cold place the flask in warm water for a few minutes and remove the plate from the investment, cut off the surplus metal with a fine saw and finish in the

usual manner. Fig. 1103 illustrates a lower case ready for mounting teeth, and shows the manner of roughening the plate so the rubber will attach itself more firmly. Fig. 1104 illustrates a finished case

FIG. 1104.

and Fig. 1105 a finished case with rim. Figs. 1106 and 1107 finished cases cast on to gum sections.

FIG. 1105.

"To repair, cut away metal enough to let the new tooth or block go in place, touch the margins with chlorid of zinc, invest as for a

FIG. 1106.

new piece, and pour. When the break is very slight, some mend with a blowpipe, using beeswax as a flux, with the metal as a solder, or,

make an undercut in the region of the pins, fill with rubber, warm the tooth or block, press to place, and vulcanize. It may also be repaired with a small soldering iron, using wax for a flux and Watt's metal for the solder. In repairing the metal should be made hotter than for casting a new case.

"Most beautiful upper or lower plates may be made by combining

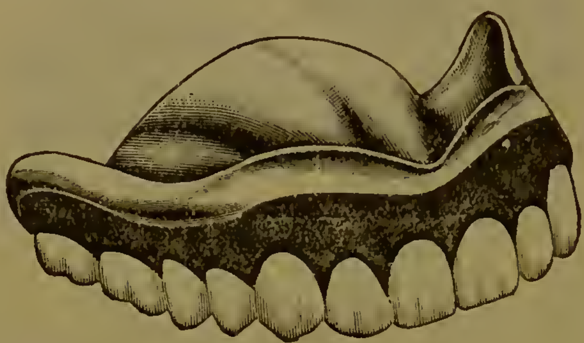

FIG. 1107.

it with rubber or celluloid, when there would be too much weight in using the metal alone."

When the process of constructing artificial dentures of these alloys is properly conducted from the beginning up to the point of pouring the metal, the piece will come from the matrix perfect in all its parts. But when the metal fails to flow freely around the teeth, and to cover perfectly the alveolar border and palatine arch, it is better to replace

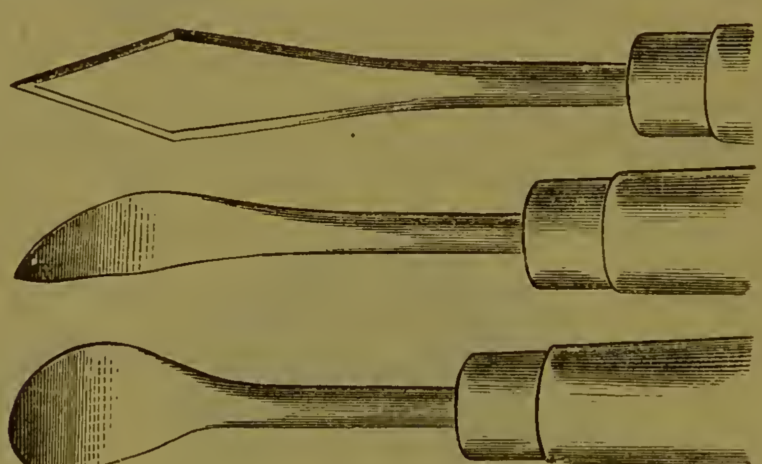

FIG. 1108.

the removed half of the matrix; then, turning the gate down, heat it up to the melting-point of the metal, place again in the sand-bath, and pour a second time. Attempts are sometimes made to patch the plate where the defects are small; but it will prove far more satisfactory in the end to pour it entirely anew. The matrix should become entirely cold before any attempt is made to remove the piece; otherwise there

will be danger from the sudden exposure of warm teeth to the air. The plaster mixture is easily cut; dipping it in water will make it softer and more easily removed.

If care has been used in shaping the wax plate, if the plaster has been kept free from air-bubbles, and if the joints between gum teeth or blocks have been nicely jointed and filled on their front edge, with

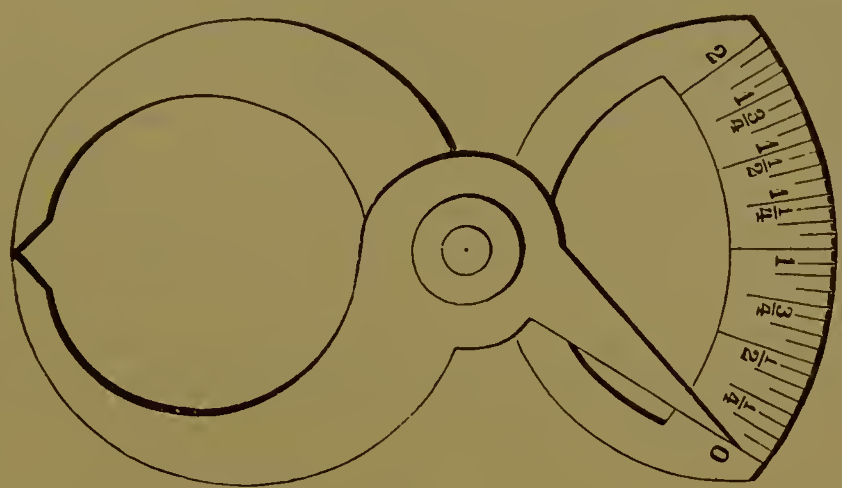

FIG. 1109.

the plaster moistened with soluble glass, the piece may be finished with little trouble. The gates and vents and irregular edges of the plate may be sawed off or removed with coarse files; fine-cut files became clogged with the metal. Scrapers (Fig. 1108) may be employed for removing the roughness of surface—curved or rounded for the inner surface, flat, straight-edged, and pointed for outer surfaces or

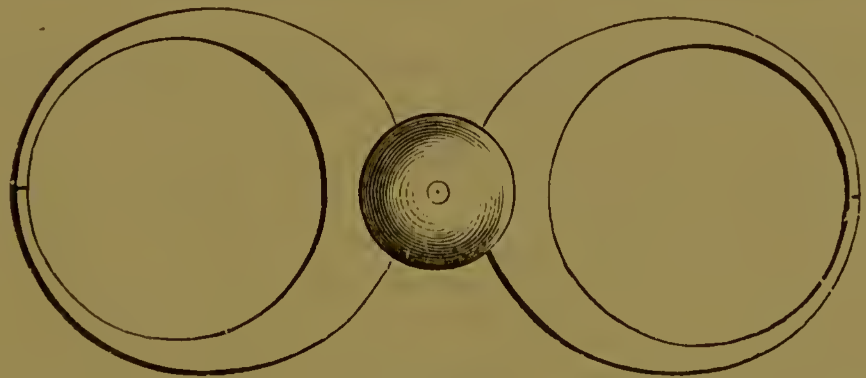

FIG. 1110.

dental interstices. If carelessness in making the wax plate renders it necessary to cut away much thickness of metal the lathe burs used for vulcanite will be found useful. In reducing the thickness of plates frequent use of calipers (Figs. 1109, 1110) is necessary to avoid the accident of cutting through the plate. This is especially apt to happen in the use of lathe burs. Fig. 1110 should have the tips on one side pointed, as in Fig. 1109, and they should be occasionally exam-

ined to see if both sides come together alike. It will make the use of calipers more easy if the arms are kept permanently open by an elastic band, closing by pressure of the fingers at each trial of the plate. Graduated calipers are useful also for measuring the depths of articulating rims, the length of teeth, etc., and are quite indispensable. This done, the surface is rubbed first with coarse and afterward with fine emery cloth, then washed in soap and water with a hard brush, afterward burnished and finished by polishing with chalk on a brush wheel; coarse Scotch stone may be used in place of the emery cloth. The upper surface of its plate must neither be scraped nor polished, as the accuracy of the adaptation to the gums and palatine arch would be injured; it should simply be washed well with a brush, using, perhaps, a little whiting. Every other part ought to be finished in the neatest and most perfect manner; the piece is put in a strong solution of caustic potash, boiled for two or three minutes, then washed in pure water, wiped dry, and finished with chalk and the brush wheel.

Under no circumstances should the tin alloy be gilded. The least imperfection of the electrotype deposit, or the abrasion of any edge of prominence, or the removal of the coating by trimming the plate at any point, presents to the fluids of the mouth two metals having widely different galvanic relations; electric action is inevitable, causing decomposition of the plate, annoyance to the patient, and often ulceration of the gum. The tin alloys are quite harmless in the mouth. They all slightly tarnish, but the surface oxid seems to protect from further action, except where abraded by the mastication of food. The brilliant polish of new work cannot be kept so long as on a gold plate, because it is much softer; this, however, is of secondary importance, provided the metal is hard enough to resist wearing away under the necessary operations of use and of cleansing.

In mounting a set of teeth for the lower jaw the gate through which the metal is poured into the matrix should have two lateral branches, one on each side, to admit the metal more freely. The wax plate should also be thicker, to give sufficient strength and stability to the base; in other respects the process is the same as that described for an upper set. For a partial lower set of molars and bicuspids on each side the wax plate should be extended behind the remaining front teeth; and two or three thicknesses should be applied here, giving stiffness sufficient to prevent breaking or bending under the pressure of mastication.

In making an antagonizing model for an entire set of teeth the wax plate for the lower jaw is stiffened by the adjustment of a stout iron wire, bent to the curvature of the arch, and made fast to and partly bedded in the plate. The rim of wax is now arranged on the ridge,

and after being properly trimmed it is taken from the model. Upper and lower plates are then adjusted in the mouth, the articulation is obtained, and the articulator (Fig. 1111) made in the manner described for a full set of teeth mounted on gold plate. Fig. 1112 represents a double set of teeth arranged in wax upon a plaster articulation, ready to be placed upon their respective models preparatory to the formation of the remaining halves of the matrices. The cast base process is also applicable to partial sets of teeth; a single tooth or several teeth situated in different parts of the arch can be replaced, and retained so as to occasion no inconvenience or annoyance to the patient. The only precaution necessary to be observed in their construction, in addition to that of accuracy of adjustment and neatness of execution, is to thicken the projections of the wax plate between the remaining natural teeth sufficiently to give strength to the metal at these points. These portions, when very narrow, should have twice the thickness of the other parts of the plate. Clasps cannot be used,

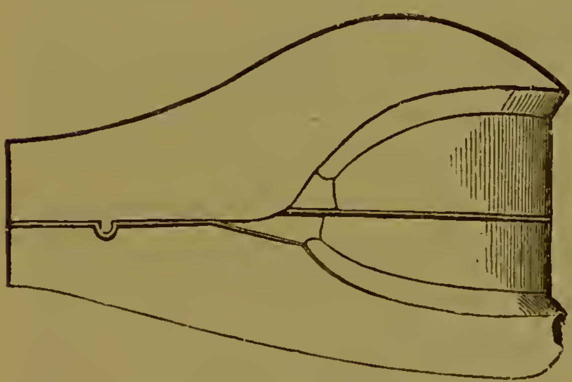

FIG. 1111.

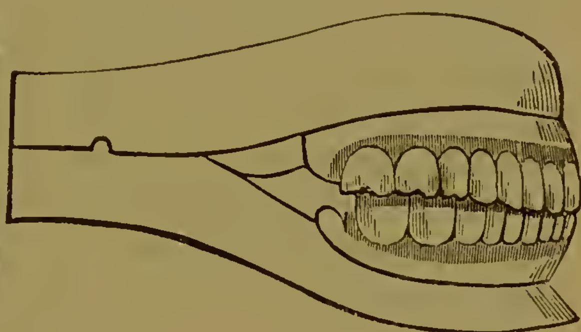

FIG. 1112.

as the metal itself has no elasticity, and gold clasps could not be connected to such plates. With this exception the forms of partial pieces for this work are the same as for vulcanite work, hereafter described. After having adjusted the artificial teeth and made them fast to the wax plate the teeth of the model should be cut off before making the other half of the matrix, as it would be almost impossible to separate the two halves without breaking the teeth and other important parts.

But if proper flasks are used it is not necessary to cut off the teeth. In the same manner as hereafter described for that work, the model may be set in the deep half of the flask until the edges of the teeth are nearly or quite level with the edge of the flask; the investing plaster supports the outside of the teeth and prevents breakage on separating the flask.

A piece from which one or more teeth have been broken can be easily repaired. If any portion of the tooth remain it is removed, and the metal that united it to the base filed away; a new tooth is

selected and ground until it corresponds with the adjoining teeth; it is then put in place and wax applied on the outside and inside of the tooth, smoothing it with the warm wax-knife evenly with the plate. The apex of a conical-shaped roll of wax about an inch and a half in length is united to the wax on the back part of the tooth; the apex should be little more than an eighth, and the base half an inch in diameter, which latter should be half an inch above the edge of the teeth. A small stem of wax is united to the wax on the outside of the tooth with the free extremity half an inch above its edge. The one-half of the flask is now filled full of the plaster mixture, and the piece put immediately in it with the base downward, first filling the irregularities of the plate with the plaster; the top or other half of the flask is then put on and a thin mixture of the same composition is poured on top, filling the ring and covering the edges of the teeth about a quarter of an inch. When hard the projecting stems of wax are withdrawn; the wax on each side of the tooth and between it and the base will be melted and absorbed during the drying process. The matrix is dried in a stove or furnace, being careful not to heat it up to the point of fusion of the plate. The alloy is then melted and poured into it through the gate behind the tooth, and if it flows, filling the vent in front without bubbling, the piece will come from the matrix perfectly restored. When cold the plaster mixture is broken from the teeth and the metal around the new tooth finished according to the direction given for full sets. In repairing pieces the heating of the matrix and metal must be done very carefully. If the matrix is too hot, the plate may fuse; if too cool and the melted metal too hot, the porcelain may be cracked. In using tin alloys in connection with platina pins it should be remembered that the exposure of a single rivet to the action of the buccal fluids forms a galvanic battery, which will cause an unpleasant taste and render the piece liable to slow decomposition; hence all pins must be carefully covered with metal, so as not to be exposed in the finishing processes.

Sets of teeth may be made of these alloys which, after cutting off the gate and vents, are ready for the emery-cloth and brush-wheels. This result can be uniformly secured by care in shaping the wax and proper attention to temperature in pouring. These alloys have a slight shrinkage, not sufficient to break blocks or chip the edges if the directions above given are observed. The slight shrinkage may give these plates an advantage over vulcanite in point of adaptation.

The strength of the Wood or Weston metals permits their use for partial pieces and allows stays to be formed on the plate; but full clasps cannot be made because alloys of this class are not sufficiently elastic. The form of such plates will be discussed in the next chap-

ter. In preparing the above directions we have discarded some innovations upon other processes as being anything but improvements; such, for instance, as the recommendation to heat to 210°, or, "so that it can hardly be held in the hand," a flask containing teeth on to which a metal is to be suddenly poured at a temperature of 440°. This temperature may be quite sufficient, however, for some of Dr. Wood's alloys. The safest rule in all cases, except for repairs, is to heat up to the fusion point of the alloy. As an offset to this error we notice a good suggestion for removing small remnants of wax by washing out with hot water. It has an advantage over the plan of allowing the hot, dry plaster to absorb the wax, in permitting examination of the pins and joints and allowing closure of front joints with plaster; also by enabling the mold to be thoroughly cleansed just before closing it prevents the accidental retention of small particles of plaster which may interfere with the flow of the metal.

Aluminum or *Aluminium Work.*—This metal is in nearly all works on chemistry called Aluminium, making it similar in termination to twenty-three other metallic bases discovered by modern science and known by Latinized names ending in *ium.* None of these, however, have any practical value in the arts as metals, except cadmium, magnesium, palladium, rhodium, and iridium.

Sir Humphrey Davy inferred from his discovery of sodium and potassium that alumina was the oxid of a metallic base. This conjectural metal, named Aluminium, was subsequently discovered by Wöhler, but remained for more than twenty years a mere chemical curiosity, until in 1854 St. Clair Deville succeeded in manufacturing it in large ingots by the action of sodium upon the chlorid of aluminium; but the cost of metallic sodium made this an expensive process. He subsequently obtained it by the action of chlorid of potassium upon the once rare mineral, Cryolite—an alumino-fluorid of sodium, large deposits of which have been discovered in Greenland.

It is the lightest metal known except magnesium (excepting also, of course, sodium and potassium); its specific gravity is 2.56 for cast metal and 2.67 for hammered metal, about the weight of glass or porcelain. Its point of fusion is somewhere near 1000° Fahrenheit. It is malleable, laminable, and ductile in a high degree; has a hardness equal to silver and excels it in point of tenacity; it is eight times better than iron as a conductor of electricity, being nearly equal to silver. Unlike silver, it wholly resists the action of sulphur, also of nitric acid, unless it is boiling. Sulphuric acid does not affect it, nor do the vegetable acids, as citric, oxalic, and tartaric. Its proper solvents are hydrochloric acid and chlorin. It is somewhat affected by the caustic alkalies, soda, and potash; also, perhaps, by ammonia and

quicklime. A solution of salt and vinegar is said to affect it, possibly due to a liberation of the chlorin in the salt.

Its record of resistance to change by acid and alkali is a very fair one, and gives rise to the conjecture of possible impurity of metal in explanation of the cases reported in which aluminium plates undergo change in the mouth. The conjecture is strengthened by the peculiarity of this change; it occurs in spots, seeming to indicate some local impurity or alloy, not by a general discoloration of the plate, such as we see on eighteen-carat gold, or silver, and on the stannic alloys. The subject of aluminium alloys in connection with the mouth and as solders is an open field of inquiry, and researches may some day be crowned with the discovery of an aluminium base plate equal in all respects to gold plate, with the peculiar advantage of its remarkable lightness. Present experience is unfavorable to its power, in its pure state, of resisting the buccal secretions.

Aluminium plates may be swaged, teeth backed and soldered by the blowpipe, just as in gold work, but its soldering requires great care. For many years all formulæ of solders for this metal proved very unsatisfactory, and but recently it was discovered that the chlorids of silver and cadmium acted well as fluxes in soldering aluminium. The most successful solder which has attained any extensive use is that of Joseph Richards, of Philadelphia, which can be used with the blowpipe or with a soldering iron.

When used with the blowpipe or soldering iron, the surfaces to be united are first scraped clean and then tinned with the solder itself by rubbing it on hard with the copper soldering iron; the prepared edges can then be easily soldered together, using the hot copper iron and no flux. This solder consists of an alloy of zinc, tin, aluminium, and phosphorus, the zinc and tin constituting the bulk of the mass. When this solder is to be used with the blowpipe, a little silver can be added to it to give a better color. The swaging of aluminium is done just as in the case of gold or platinum, except that frequent annealing is necessary. The annealing must be done with extreme care, since the fusion point of the metal is so little above red heat that the slightest excess of heat will warp, blister, or melt the plate. For the purpose of annealing it is suggested to coat the surface of plate with oil, and then pass it over the flame of a spirit-lamp until the oil is burned off and the plate becomes white, when it is instantly withdrawn. The extreme lightness of this metal permits the use of a plate two or three times the thickness of gold plate; hence aluminium plates may be the very strongest that can be made in any given case. The best method yet proposed for attaching the teeth to such a plate is by vulcanite, the details of which process will be given in the next chapter. It is a

peculiarity of pure aluminium that vulcanized rubber adheres to it with great tenacity. A set of well-chosen block teeth, skillfully arranged and secured to an accurately fitting aluminium plate, may safely be offered to the most fastidious and critical patient. It has, moreover, the great advantage that "sixty-minute" dentists will not care to imitate work which takes "several" hours to do even passably well.

Another form of aluminium work, and that which has led to the present classification of this metal under the head of Plastic work, was the molded or cast aluminium plate. No experiments, however, seem to us to have been conducted with such care as those of the late Dr. James B. Bean, of Baltimore, who perished under an avalanche, in the summer of 1870, while ascending Mont Blanc; and his process was not only a difficult one to pursue, but was very uncertain in its result; hence the use of aluminium is not at the present time attempted except in the form of swaged plates to which the teeth are connected by vulcanized rubber, and which is referred to in the article on Vulcanite.

Aluminium Cast Base.—Dr. C. C. Carroll uses a prepared form of aluminium which he describes as being first made pure to prevent disintegration, and then alloyed with a small per cent. of noble metals that expand in cooling and thus compensate the contraction of the aluminium. He describes his method as follows:—

"*For a Rubber Attachment.*—Base No. 1: Take an accurate impression in plaster, or modeling composition, outline on the impression the limit to be covered by the denture as intended to be worn. Place a strip of our No. 1 base plate wax, ½ inch wide, across the posterior palatine arch of the impression, terminating and shading out at the alveolar palatine border. This wax strip, when reproduced in aluminium, closes the posterior palatine arch of the cast denture, which by virtue of the slight contraction of $\frac{1}{120}$ part impinges firmly on the alveolar ridge, while it lifts slightly from the central posterior arch, making a denture that rests firmly in place without rocking. Pour the impression thus prepared with our investing compound mixed to the consistency of thick cream, and get a model, on which cut a narrow line $\frac{1}{32}$ inch deep and the same width, extending from the wax strip imprint around the alveolar palatine border, to constitute all the air chamber that should ever be made in an aluminium cast denture.

"Take a thin sheet of our No. 1 wax base plate, about No. 23 standard gold gauge in thickness, and shape neatly on the model a temporary base plate as intended to be worn. Surround the entire palatine and labial alveolar border, near to the line that the teeth are to occupy, with a thin strip of paraffin wax about ⅛ inch in width;

fasten and smooth down the outer edge of this strip with melted wax; then with a thin wax knife raise the inner edge all around next where the teeth are to be arranged, which wax strip, when reproduced in the metal base plate, will be a flange or undercut, surrounding the teeth to hold the celluloid or rubber attachment for fastening the teeth to the permanent metallic base plate.

"Contour, carve, and smooth neatly to the form desired. Now make the matrix by imbedding the model with the temporary base plate upon it, in the female part of the flask, allowing the investing

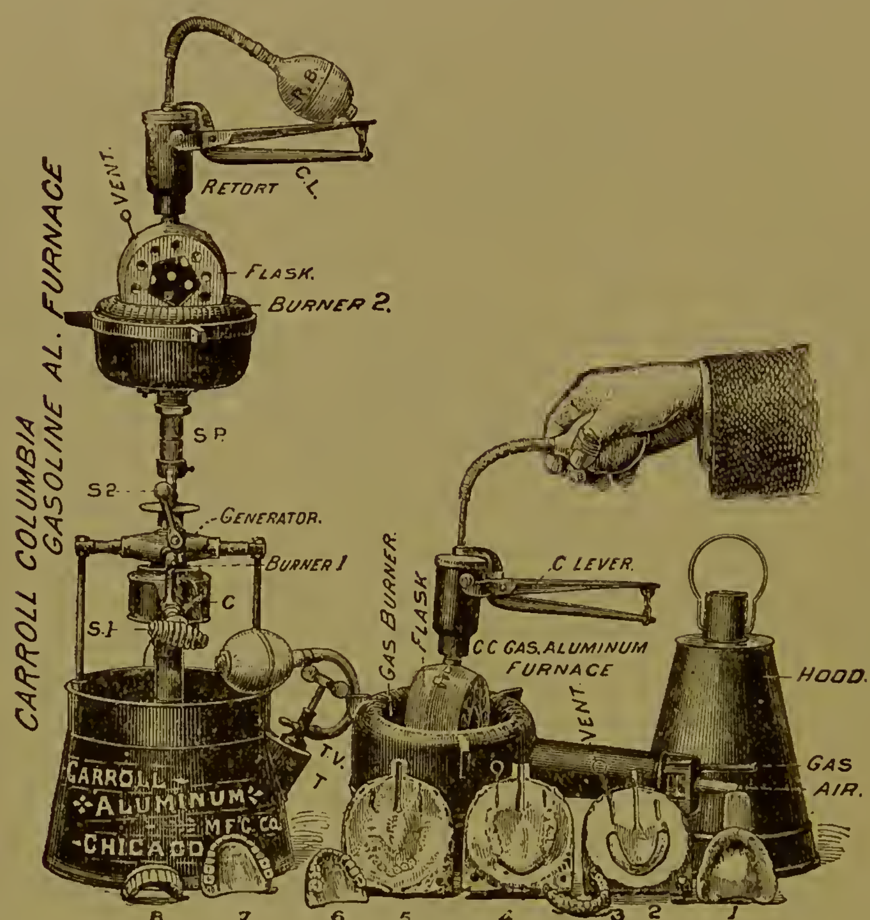

FIG. 1113.

material to come up to the edge of the base plate. When set, smooth the investing material and cut a gate from the middle edge of the base plate to the pouring point of the flask; also cut short gates about one inch long in a perpendicular line from the heels. The gates, when finished, should be nearly round, about $\frac{3}{16}$ inch in diameter. Connect one gate with the vent cut in the flask.

"Dust the surface of the matrix with pulverized soapstone, and polish the surface by rubbing with the finger. Mix enough investing mate-

rial to fill the other half of the flask; pour first so as to cover the base plate and matrix, jar to expel the air, and then pour into the male part of the flask, place the two parts carefully together, and force into place, squeezing the excess through the perforated back of the flask. When set and hard separate and remove the temporary base plate, washing out the wax with hot water. Take great care that the wax is not melted before separating, and absorbed into the matrix to generate gas that will prevent a perfect cast of aluminium.

"Cut the gates in the male part of the matrix, as indicated, to correspond to the female part. Cut out the plaster from the pouring point. Bolt the flask firmly together. Coat the thread of flask with soapstone. Screw the retort firmly to flask. Place the fine copper wire in the vent. Then lute the seam of the flask and where retort joins the flask, also around the bolts, with investing material, to prevent the escape of air or metal in casting. Test with the rubber bulb and clamping lever: See if matrix is air-tight. Soapstone sprinkled over suspected leak will determine the test. Withdraw the wire from the vent and test again to see that only the vent is open. Place the flask in the slot of the burner, turn on low flame, and dry out thoroughly, as will be shown if no moisture appeers on the surface of a mirror held over the retort.

"When the piece is dry, place the flask on the bottom of the burner; put two ingots of Aluminium Base No. 1 in the retort, place the hood over it, and turn on full flame, and with use of foot bellows attached to air tube of the burner proceed to melt the metal, which will usually require from six to ten minutes.

"When melted, remove the hood, turn off the gas, and clamp the retort cover in place with clamping tongues, slipping the ring over handles, then with the rubber bulb pressed gently but firmly force the melted metal into the matrix, until metal is forced through the matrix at the vent; chill the metal with piece of wet sponge tied to a stick as soon as it appears at the vent. Press three seconds to condense the metal under pressure in the matrix. Make an ingot mold by filling a pepper box with investing and boring a tapering hole of less diameter than the retort. With the handles of the clamping tongs unscrew the retort from the flask as it stands in the burner, and with bulb blow out all excess aluminium from the retort, so that the opening through the bottom is clear.

"*For Casting Directly on Teeth.*—When it is desired to cast directly on plain teeth, which are preferable to section teeth, place the model prepared as above described upon the articulator, after obtaining a correct articulation in the usual manner. Mount the teeth on the No. 1 wax base plate, as is usual for rubber work, except that the teeth

must be spaced so that a postal card will pass between them when mounted. Wax up contour and carve neatly, with a double curved end wax knife, exactly as intended to be worn, leaving the lingual surface of the wax base plate unmarred as you would have the aluminium plate come out finished, remembering that the wax form will be accurately reproduced in aluminium.

"If it is necessary to have an artificial gum, which very rarely happens if plain teeth of the proper pattern are selected, then place a narrow strip of base plate wax, $\frac{3}{16}$ inch wide, around the alveolar border only, for a flange, between which flange and the ends of the teeth a pink rubber facing may be attached.

"Remove the model with the mounted denture and proceed to invest as described for a base plate alone. After washing out the wax, make a thin cream of equal parts carbonate of magnesia and prepared chalk, with water, and with a small camel's-hair pencil cover the alveolo-labial edge of the teeth with a thin coating of this cream, to prevent the metal from flowing over the edge and possibly checking the teeth.

"Bolt the flask together and dry out the case, and make cast as directed for base plate.

"If the gum section teeth are used, grind the feather edge slightly beveled, leaving the labial edge of the gum highest, and mount, spacing slightly by placing heavy writing paper between the joints. Before investing, remove the paper and flow between the joints the magnesia and chalk cream above given. Then invest the same as for plain teeth. After washing out the wax, flow a thin film of the above cream along the beveled edge of the gum, close the flask, dry out, and proceed to cast as directed.

"If at any time the crucible passage becomes stopped, before making another cast heat the crucible to a bright red and blow out the obstruction; otherwise metal being left near the outlet of the passage would form a siphon, and empty the chamber of any metal in it designed for a subsequent cast.

"Let the cast cool slowly; separate the flask and remove the cast from the investment. With a fine saw and cutting pliers, trim away all surplus metal from the cast. Coarse finish with files, cone burs, and sand paper. Burnish and remove scratches with pumice and water, and finish with polishing compound on brush and buff wheels.

"If a base plate has been cast, use this finished base plate for a trial plate; with wax placed along the flanged alveolar border, obtain the correct bite and articulation. Mount the teeth as desired, waxing up for celluloid or rubber attachment, and proceed as in celluloid or rubber work.

"*Directions for Base No. 2.*—Proceed in all respects as if for rubber work, using thin paraffine wax for temporary base plate until the teeth are mounted on the model. Trim and wax up neatly and light as intended to be when finished for the mouth. Then invest the model and the teeth in perforated flask and proceed as directed for Base No. 1 up to the point of making the cast. When the matrix is dry and ready to make the cast, place two ingots of Base No. 2 in the retort with the larger opening. Stop the opening with an old plugger to prevent the metal escaping as it melts. When all is melted withdraw the stopper and chill the metal when it appears at the vent. Turn on flame enough to melt the metal in eight to ten minutes, which requires not over half the flame needed for Base No. 1. If there should be any point of leakage of metal it can be stopped at once by touching it with a wet cloth, and any escaped metal can be immediately remelted and poured into the matrix without producing any flaw or imperfection in the piece to be cast. Let the piece cool slowly, remove from the flask, and finish as directed for Base No. 1. Never use the same retort for melting Base No. 1 and Base No. 2.

"*For Aluminium Crown and Bridge Work.*—Shape the roots or teeth to which attachment is to be made for crowns or bridges the same as for a gold crown and bridge work. Then take an accurate impression in plaster, if possible, from which make a model of investing of the part to be supplied. Mold upon the supporting roots or teeth in thin paraffine wax the crown or bridge as intended to be worn, and mount the teeth desired to supply the needed deficiency with proper occlusion, in the same manner as if a partial plate were to be made, taking care to space the teeth so they shall not touch each other if the bridge is to be cast from Base No. 1. Carve neatly as intended to be worn, allowing the bridge or saddle to rest narrowly on the alveolar border, which should be slightly scraped on the model so as to fit firmly on the soft parts and thus distribute the force over the supporting roots and the alveolar border alike, at the same time precluding food from getting under the bridge or saddle. Now invest or proceed with the subsequent steps as already described for casting, according as the case may be for Base No. 1 or No. 2. Finish and adjust to the mouth either for detachable or cemented bridge, as may be desired—giving the preference to detachable bridge work when practicable. If it is to be cemented, use oxyphosphate of zinc, mixed as if to be used in filling; dry the roots or teeth to be crowned; fill the crowns; press the bridge firmly to place, keeping dry until fully set, which operation may be expedited by the use of hot air. Removable bridges and partial dentures are securely held in place by the Carroll Spiral Aluminium Coil Spring.

"*Directions for Using Gasoline Furnace.*—Use 74 degree specific gravity gasoline, fill the tank about half full, close all the openings, pump in air, open vent to the dripping-pan, S^1 (see Gasoline Furnace, Fig. 1113), swing around the cut off to the dripping pan (C), and fill about two-thirds full, which you light to heat the lower generator; when dripping-pan is burned out, swing cut-off back and open lower generator and light the gas under large generator B^1, which let run for about five minutes, then open upper generator at S^2 and light the gas at the burner B^2, keeping the lower generator burning just high enough to heat the upper generator while in use. Keep water in the reservoir above the tank in order that the tank may not heat. Mount, invest, and cast as directed for gas outfit."

Gold Alloy Cast Base.—Dr. G. F. Reese has recently devised an alloy composed of gold, one part; silver, two parts; and tin, twenty parts, which is manipulated by a special method, as a base for artificial dentures, and which has met with considerable favor. A brief description of Dr. Reese's method is as follows: A plaster model is first obtained from a plaster impression of the mouth, and on the model a trial plate is made of gutta-percha, paraffin, and wax, or of modeling composition. Upon this trial plate the teeth are arranged and tried in the mouth. If satisfactory the waxing about the teeth is completed, and the portion of the trial plate covering the palatine surface is removed to such a degree as to nearly expose the pins of the teeth, the wax under the gums being allowed to remain. For the portion of the trial plate removed two thicknesses of French flower wax is substituted, being carefully adapted to the model.

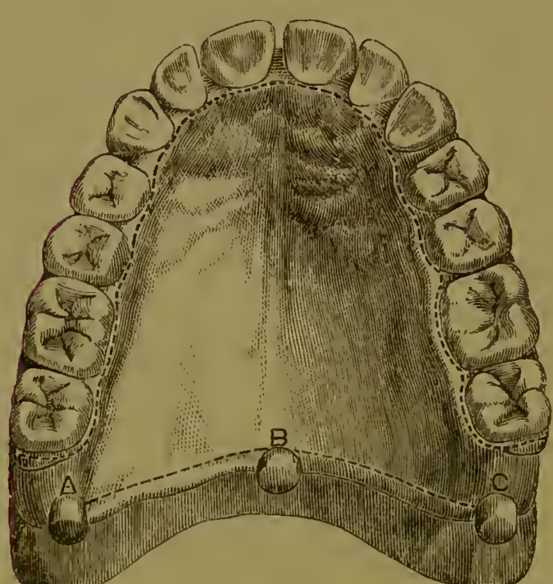

Fig. 1114.

Fig. 1114 represents a case carried to the stage described, the dotted lines showing the edges of the thin wax substitute portion, and B, A, and C prominences of wax attached to the posterior border and portion of the plate covering the maxillary tuberosities, A and C being designed for the escape of the alloy, which is poured in at B. The case is then placed in a brass flask, which has been oiled to render its removal from the investment easy. Fig. 1115 represents the case in the flask ready for investment. To invest the case each section is placed

upon a plate of glass and plaster poured in until it is half filled, when the model, which has been saturated with water, is pressed into the plaster batter until the teeth and gums alone remain uncovered. The counterpart of the flask is then set on and sufficient plaster poured in until the prominences of wax along the posterior border of the trial plate are slightly covered. After the plaster has set the upper section of the flask is removed and the surface of the plaster coated with shellac varnish. The section of the flask is then returned to its place and the investment completed by filling it up to the edges with additional plaster. When this has set the flask is placed in hot water in order to separate the sections easily. The wax is then removed and also the

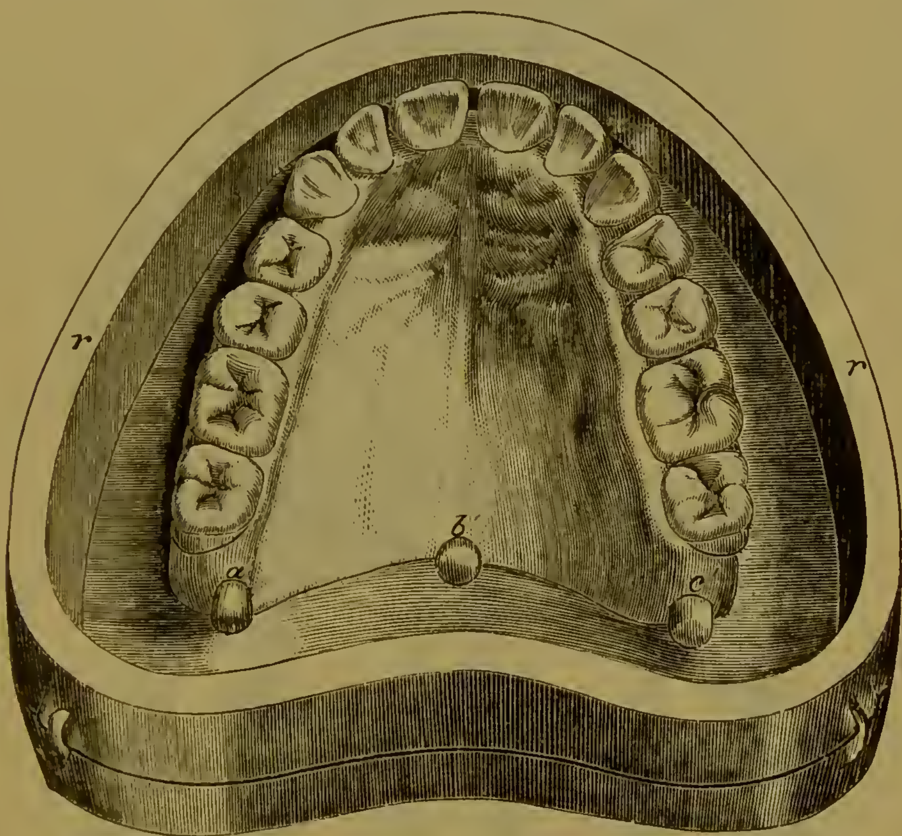

FIG. 1115.

sections of the flask by gently tapping them, and communication made from the outer surface with the cavities left by the wax prominences along the posterior border of the plate; or, if this is impossible, the vents and gates may be formed at the line of division between the sections, as represented by the dotted lines in Figs. 1116 and 1117. Externally the openings D, E, and F, Fig. 1117, should be enlarged by reaming out the plaster and varnished with shellac, to receive the cylinders, which latter are made of wax, rolled thin, and wrapped around a cone-shaped piece of wood. These cylinders are about one and a half inches long and about half an inch in diameter at the base, tapering to an eighth of an inch at the apex.

The pouring-cylinder is usually made somewhat smaller at its base than the others, but some two inches long. Wax covers are attached by a warm spatula to the larger ends of the cylinders, so as to make them water-tight. Fig. 1116, *d*, *e*, *f*, shows the cylinders thus prepared and attached. In case the openings have been made through the plaster investment of the lower section, as represented in Fig. 1116, then the upper section, Fig. 1117, need not be united to it

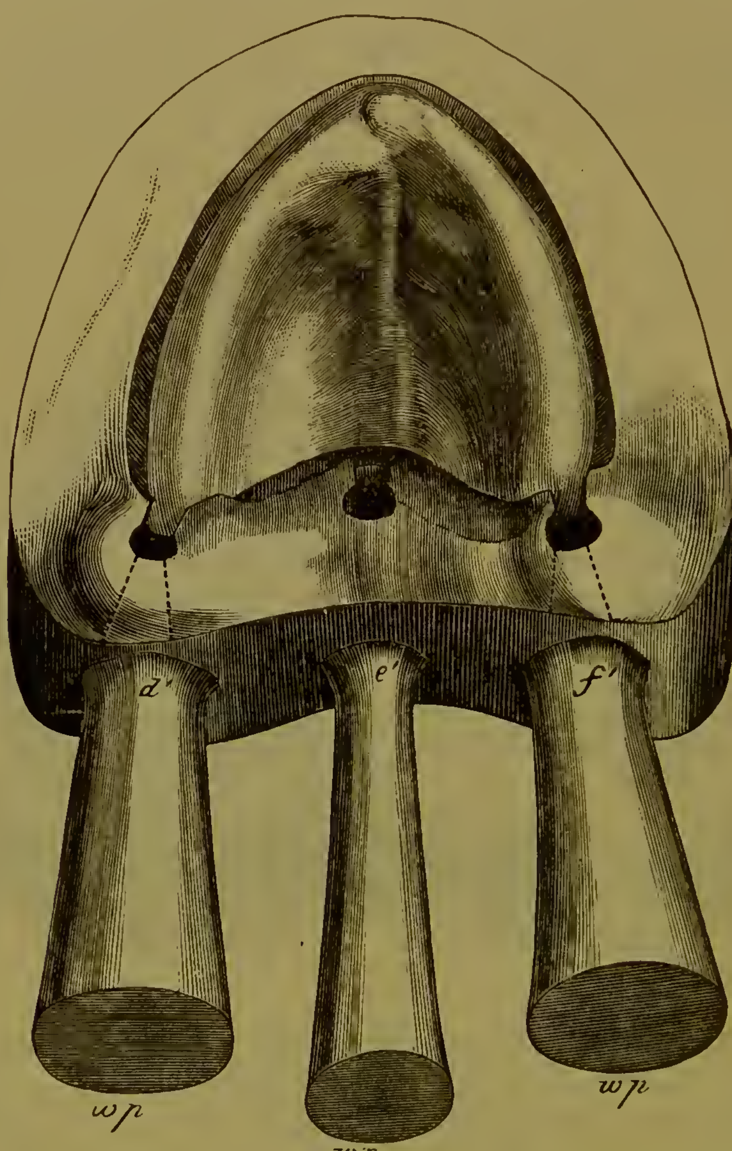

FIG. 1116.

until the openings have been formed upon the line of division, when the sections must be joined before the cylinders can be attached. The case is then placed in a larger flask, Fig. 1118, and invested as before, allowing the end of the pouring-cylinder to rest in the opening of the posterior border of the flask. In this investment there is no division of the sections after the parts of the flask are filled. The case is then

dried in an oven, all of the wax being absorbed by the heated plaster, until all moisture is expelled. Several grades of the alloy are used by Dr. Reese, which melt at 600° to 700° F., but a higher temperature is

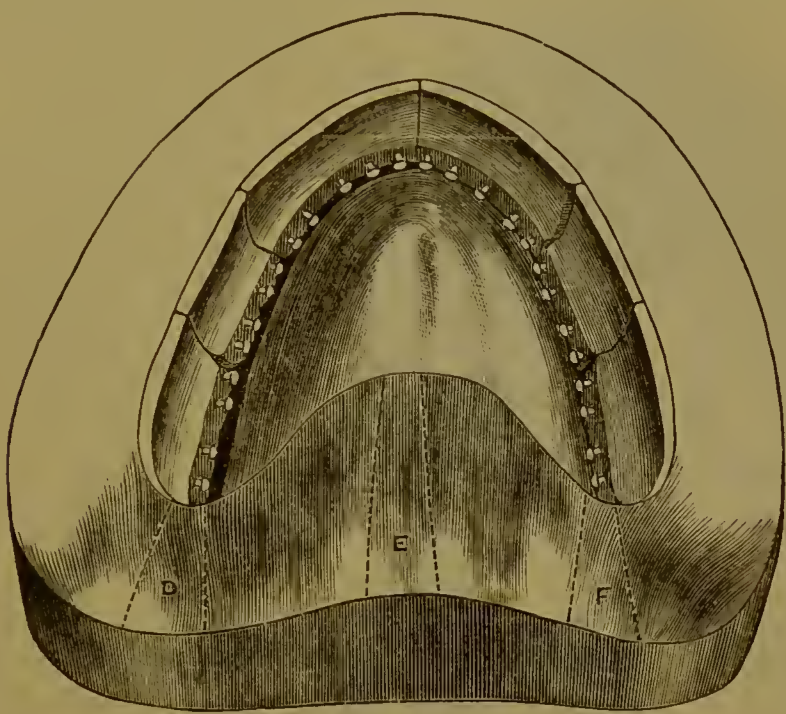

FIG. 1117.

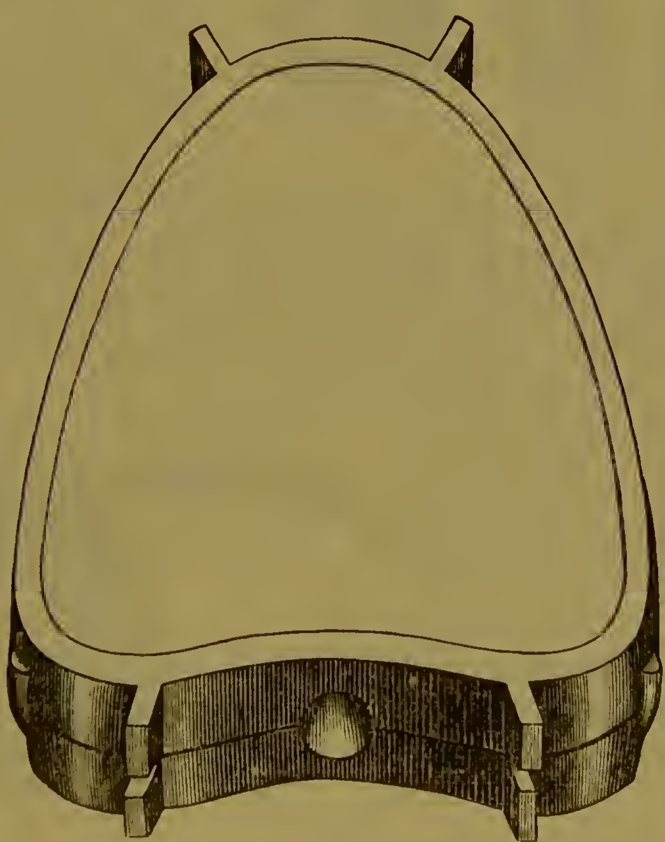

FIG. 1118.

necessary before the metal is ready to pour. A temperature of 900° F., however, will cause rapid oxidation, which, of course, should be

avoided. An ordinary ladle may be employed to melt the alloy, which is poured at the proper temperature into the opening of the flask and investment. When sufficient time has elapsed for the metal to cool, the flask is opened and the case presents the appearance represented by Fig. 1119, when it is ready for finishing, the surplus alloy being removed by a saw, and the surface of the plate polished by pumice on a wheel and brush.

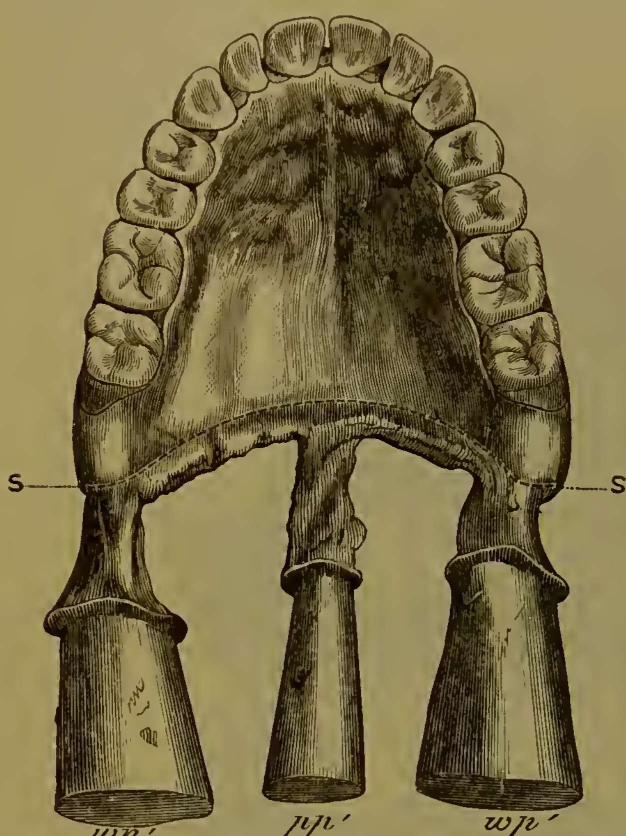

Fig. 1119.

To repair this work all edges are scraped clean, and a space cut between them of about one-eighth of an inch, which is filled with wax when the set is adjusted on the model. At each end of the space two cones of wax, each about one-eighth of an inch in diameter, are attached, standing perpendicularly to the palatal surface, and the whole invested with plaster to the depth of an inch. The two sections thus made are then separated, and the wax is washed out by boiling in hot water. The external ends of the spaces left by the wax cones are then countersunk and a larger wax cone is inserted into each opening, the one to form a pouring-gate and the other to act as a vent for surplus metal, this last being entirely covered by the plaster of the investment. The entire piece is then invested in a repair-flask, and the plaster thoroughly dried and heated up before the alloy is poured.

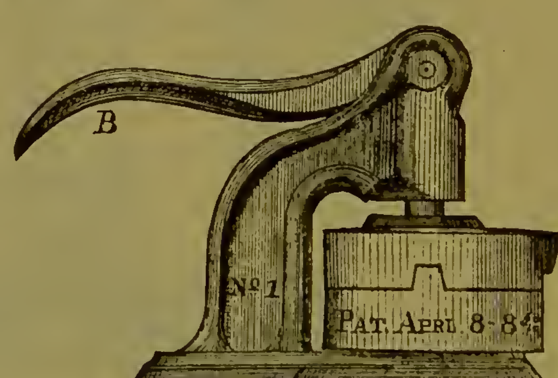

Fig. 1120.

Fig. 1120 represents a dental mold designed by Dr. Hayford for use in manipulating Weston's, Watt's, and Hayford's alloys and by which it is claimed all imperfections caused by air bubbles or failure of the material to cast sharply

are overcome. The metal is introduced with the flask partly open, and just before crystallization commences pressure is applied by means of the lever, which closes the flask and forces the material into every portion of the mold, producing a sharp, perfect casting.

Ward's Electro-Metallic Dentures.—A process of depositing by the action of a battery gold and silver directly upon the surface of the plaster model obtained from the impression of the mouth, and thus securing perfect adaptation, has recently been introduced. The surface of the plaster model is prepared for the deposit of gold by coating it with plumbago. A definite thickness of gold is first deposited on the plumbago-covered surface of the plaster model, and upon the gold a deposit is then made of silver, which in like manner is then covered by another deposit of gold. The object of using silver as an intermediate layer between the two gold layers is to give strength to the plate, as all deposited metals are deficient in that respect, but silver less so than gold. Sometimes a thin silver plate is swaged and the gold deposited upon it. Any desired thickness of gold can be deposited. If a rim is desired on the plate the edges of the impression are cut down and shaped accordingly before the model is poured. A plate so constructed must not be soldered, as the heat will anneal it to such a degree as to render it too pliable; hence in a set of full metal the teeth are attached by depositing gold about and around their pins, and the backings are portions of the deposited metals and continuous with the plate. This process is applicable for full and partial dentures of all metal finish and for combination with rubber or celluloid, in which case a portion of the surface of the plate—that covering the alveolar ridge—is so formed as to present projections of the metal in the form of retaining-points for securing the vulcanite or celluloid which attaches the teeth and forms the gum portion. It can also be applied to capping crowns or cusps and to removable bridge-work.

VULCANO-PLASTIC WORK.

Under this name are included all vegetable materials which have been, or may hereafter be, incorporated with sulphur, iodin, or other substances for the development of those peculiar properties so well known in hard rubber. Inspissated linseed oil, amber, and gum copal, etc., have thus been experimented with, but with results thus far very unsatisfactory. They are here mentioned because it is by no means improbable that among the vegetable oils, resins, or gums, now known or to be discovered, there will be found one which shall excel any yet known in those remarkable qualities imparted by sulphur to the resinous gums, gutta percha, and caoutchouc. These differ from some other resins in an opacity which follows them through their

combinations with sulphur, making it impossible to obtain even a tolerable imitation of mucous membrane. Possibly some as yet unknown vulcanizable transparent resin may be found carrying into its combinations enough of translucency to give that peculiar, life-like animation which now characterizes porcelain-gum colors alone. The history of caoutchouc teaches us that it is not impossible we may be in daily use of some such gum or resin. The only compounds of gum (more strictly, resin) and sulphur that have been tried to any extent are corallite and vulcanite—the trade names of sulphuretted gutta-percha and sulphurated caoutchouc; also spoken of as sulphid of caoutchouc, because the new properties developed by the union are such as make it appear to be a true chemical compound, and not, like the vermilion, etc., often incorporated with it, a mechanical mixture.

Corallite.—Gutta-percha is the resinous exudation of a forest tree, the *Isonandra Gutta*, found extensively in Sumatra, Borneo, and the Malayan Peninsula. It was first brought to the notice of the Europeans by Dr. Montgomerie, of Bengal, in 1842, and in a few years attracted much attention for those valuable properties which have since made it so indispensable to the dentist. Twelve years ago experiments were made with it in combination with sulphur. Combined with half its weight of sulphur, and the compound then mixed with half its weight of vermilion, it formed a substance known as "Corallite," which hardened under the same conditions as vulcanite, and of which it promised to become a formidable rival.

Unfortunately, one property of crude gutta-percha followed it into this combination—its tendency to become brittle. It is well known that sheets of this substance, whether the pure crude gum or that prepared for dental use by large admixture of foreign matter, will become in time so brittle as to break almost at a touch. The vulcanized gutta-percha has the same property in less marked degree, but quite enough so to be fatal to its pretensions as a rival of vulcanite. Hence corallite is no longer avowedly used, and even its name is almost forgotten. So persistent is this injurious property that it will affect any rubber compounds with which it may be mixed. Any suspicion of the presence of gutta-percha should condemn sulphurated caoutchouc for dental use; this last-named gum, however, may be brittle and worthless from admixture of other substances besides gutta-percha, as will be hereafter stated.

VULCANITE.

Caoutchouc, formerly known as elastic resin, and still more universally known as India-rubber, was discovered by certain French Academicians in Cayenne in the year 1735. For many years its only known value was as an eraser of lead-pencil marks. Dr. Priestley, the

distinguished discoverer of oxygen, in the preface to his work on Perspective, published in 1770, speaks of it as being excellently adapted to the purpose of wiping from paper the marks of a black-lead pencil. It was still many years after this that it was confined to this use and to the making of rubber shoes and bottles by South American and East Indian natives, who formed them on clay molds from the fresh exudation of the *Siphonia cahuca Jatropa elastica*, or *Ficus elastica*. Upon discovery of a solvent, its uses were extended by bringing to bear the skilled labor of civilization; but the fact of its becoming hard and rigid (yet not brittle) at 48° greatly limited its value. The principal solvents of caoutchouc are spirits of turpentine, bisulphid of carbon, benzol, ether, chloroform, naphtha, and the essential oils.

Mr. Charles Goodyear's discovery of the remarkable effects of sulphur in combination with caoutchouc has, since 1840, extended the application of this gum to an almost infinite variety of uses. In certain proportions and at certain temperatures the sulphur does not much impair the remarkably elastic and flexible property of the native gum, but preserves it at low temperatures. Subsequent experiments led to the discovery of hard rubber, which at first was made into combs, buttons, etc. It was thus used for a number of years before its application to dental purposes. This was first attempted as early as 1853. Mr. Bevan, a former employee of the Goodyear Company, Dr. Putnam, of New York, and Dr. Mallett, of New Haven, were the first persons known to the writer as engaged in these experiments; possibly others were at the same time thus occupied. But owing to the exceedingly cumbrous vulcanizing apparatus (Dr. Putnam's weighing twelve hundred pounds), and the absence of that knowledge of the material and those appliances for its manipulation which experience alone could give, it made very slow progress for the first few years. It has been estimated that in 1858 not more than three hundred dentists made any use of it; in 1863 it was conjectured by Dr. Franklin (then dental agent for the American Hard Rubber Company) that nearly, if not quite, three thousand employed it in their practice. At the present time, the patents restricting its use having expired, it is universally employed.

Hard rubber possesses, when prepared in greatest perfection, many qualities which fit it for use as a base plate. It is impervious to the buccal secretions and unchanged by them; it has very considerable strength, great lightness, and, when properly vulcanized, a high degree of elasticity. For some purposes in prosthetic dentistry it has no equal and for some few it is indispensable; but the merit of superior adaptation is shared by other plastic substances, and for many cases

we have shown that the fit of an old-fashioned gold plate is much to be preferred.

Dental vulcanite is usually incorporated with vermilion, to give it a color more generally acceptable than the dark brown of the simple sulphurated gum. But rubber, sulphur, and vermilion are all opaque substances, and can never themselves, or by combination with other materials, be made to assume any resemblance to the natural gum, which porcelain alone has thus far been able to imitate. The incorporation of such substances for this purpose has no other effect than seriously to impair the strength of the material. Experiments in vulcanite are much more troublesome than those with stannic alloys, and probably few will take the trouble of making them. A common formula for the red vulcanite is caoutchouc, 48 parts; sulphur, 24 parts; vermilion, 36 parts. The formula for a dark-brown vulcanite is caoutchouc, 48 parts; sulphur, 24 parts; this gives the strongest rubber. The formula for a jet black vulcanite is caoutchouc, 48 parts; sulphur, 24 parts; ivory, or drop black, 48 parts. All colored rubbers are weakened by the addition of foreign matter, as English pink vulcanite, which contains 48 per cent. of white clay. White oxid of zinc in the proportion of 47 per cent. will give to vulcanite mixed with sulphur and vermilion a deep pink color. The pink rubbers are so much weakened by the admixture of foreign matter that care must be taken when they are used to produce a more natural color of the gum portion of a denture, to prevent the pins of the artificial teeth from being covered by such rubber. From an extended series of very careful experiments by the late Prof. Wildman we condense the following statements:—

Caoutchouc two parts, sulphur one part, form a dark-brown rubber, which is the strongest of the vulcanites. Of all additions for modification of color, purest vermilion is best; it withstands heat, resists the action of sulphur, and has an intensity of color that soonest overcomes the darkness of the rubber. Being a sulphuret, it appears to have much less effect in weakening the texture of the sulphid of caoutchouc than an equal quantity of any other substance; yet it does diminish its strength in proportion to its use. English deep red and American Hard Rubber Company's red contain by weight two parts sulphid of caoutchouc and one part of vermilion. To the red and brown rubbers white oxid of zinc or white clay are added in proportions varying from .20 to .57 per cent., to produce grayish-white or pink rubber. Of these the best is Ash and Sons' pink rubber (S. P.), containing gum sulphur and vermilion, in same proportion as English deep red, with one-fourth this weight of white oxid of zinc added to tone the deep color. Black rubber is made by adding to six parts of the brown sulphid from two to four parts of the ivory black.

In the selection of rubbers we unhesitatingly decide in favor of the brown vulcanite, not from any absurd idea of the injurious action of vermilion, which we shall presently show to be perfectly harmless, but because of its superior lightness and strength. We are not justified in sacrificing these valuable qualities for the sake of colors, which not only have no greater esthetic harmony with the mouth, but which by the brilliancy of their color attract attention to this defect. We use white platinum and aluminium and yellow gold ; ivory, in old times, soon darkened, and a tobacco chewer will blacken any vulcanite plate. Why not, then, use a brown base plate from the beginning? If the vermilion rubber is used let it by all means have its natural rich mahogany color, and not the glaring brilliancy with which students delight to invest their specimens. This does very well in show cases, and is eminently adapted to those captivating exhibitions of high art where a lovely wax face opens and closes, revealing alternately an aching void and acheless grinders ; but in the mouth such bright colors are monstrous violations of good taste.

Vermilion combined with rubber cannot have any deleterious effect. In no case coming under our observation have we seen a single symptom of local or constitutional action peculiar to vulcanite, except a sensation of heat ; this we take to be an electric action, due to the fact that rubber, like sealing wax, is a powerful negative electric. It is common to brown, red, pink, and white rubbers, and there is no remedy for it. It is not a constant symptom ; some patients never feel it, some often, some occasionally—dependent, perhaps, upon the state of the electric element entering into the composition of vital force.

Pure sulphuret of mercury is reckoned by Orfila as medicinally inert. Fumigation, by *vaporizing* the mercury, gives it a medicinal activity ; but this requires a temperature of 600° Fahrenheit. Therefore, for the development of constitutional symptoms, we must have the presence of arsenic or of red lead, as impurities of the sulphuret, or the existence of free mercury.

First, as to the impurities of arsenic or red lead : they are not found in pure vermilion. But even if present such poisonous impurity would be rendered harmless, because completely invested by an insoluble coating of India-rubber. A piece of vulcanite is impervious to the fluids of the mouth ; hence no part of its substance can be dissolved and thus taken into the stomach. Any supposed medicinal action must, therefore, come from such minute particles as may possibly be worn off the lingual surface near the teeth, where bread crusts or other hard particles of food impinge. White, gray, and pink rubbers have so large a proportion of foreign matter that they are easily

abraded; but in the pure red rubbers we have thus an almost infinitesimally small quantity of vulcanite taken into the stomach, one-third of which is inert vermilion, adulterated (we will suppose) with three per cent. of arsenic, and this coated with a layer of rubber, which, as previously stated, is insoluble in water, alcohol, alkalies, or weak acids. This very minute trace of arsenic, even if divested of its envelope of rubber, would have a purely homeopathic (and, by consequence, not poisonous) action; while, if encased in rubber, which pervades every part of the material, it is absolutely inert. The same may be said of the less poisonous adulteration, red lead.

Secondly, as to the mercury: the researches of Prof. C. Johnston, with the microscope, and Prof. Alfred Mayer, by chemical analysis, have failed to discover the slightest trace in samples of the best rubber used. Prof. Wildman found sulphur sublimed during vulcanization, but not the smallest trace of mercury. We have failed by any mechanical force to press out any globules, nor have we ever, in any manipulations, seen the slightest particle of this metal, or been able with the microscope to detect it upon the surface of any finished piece. This question of the presence of free mercury in the vulcanized material may perhaps require a more extended series of experiments. It is the only agent that can possibly exert any deleterious action upon the system. That its presence is rare is proven; that it is never found can be confidently asserted or denied only after the extended observations recommended, the observers, however, being careful not to confound the minute crystals of sulphur with globules of mercury, as some have done.

Impressions for vulcanite work may be taken in plaster, wax, gutta-percha, or modeling composition. The minute accuracy of plaster is not so essential in swaged work, since the very fine lines of the model are partly lost in the die and could not be impressed on the plate; but in the vulcanite the faintest scratch is faithfully copied. The finest plaster must be used and stirred until all air bubbles are removed. Although fine plaster will give the minutest lines, yet many prefer for all laboratory use a moderately coarse plaster, which becomes hard and strong when it sets, and recommend in all cases admissible plaster to be mixed as thick as it will work well, as thin-mixed plaster expands more than the thick-mixed. The fracture of the teeth of a plaster model may be prevented by inserting small pieces of wire or brass pins in the impressions of such teeth before pouring the plaster. The absolute necessity of plaster impressions, in most partial cases where vulcanite is used, led the late Prof. Austen to devise the method, elsewhere described, of taking impressions with gutta-percha trays. The advantages of a partial plaster impression thus obtained are:

first, the exact shape of the outside of the teeth adjoining the space to be filled permits correct adjustment upon the model; secondly, the accurate shape of the inside of the molars and bicuspids, at the point where wax or modeling composition impressions drag, allows the stays or half-clasps to be closely fitted to the teeth. But it must be borne in mind that partial impressions in plaster and partial pieces in vulcanite demand for their success the utmost care and nicety of manipulation, a care which the result will fully reward. The absolute non-contraction of rubber may make wax, modeling composition, or gutta-percha in some cases a better impression-material for full sets than plaster; in fact, we recommend plaster less often for full vulcanite plates than for base plates of any other material; while in partial cases, for reasons just given, we prefer its most exclusive use.

Vulcanite models require no particular shaping except the extension of the back part an inch or more, so that the model itself may serve as one-half of the articulator. This not only saves time and plaster, but gives more accurate results, since there is no transfer of the teeth and wax plate to a new wax model. When the teeth are set in the wax plate the model is then separated with a saw from the back part and placed in the flask. In double sets the back part of one model is smoothed and the T-shaped groove cut and soaped or covered with tin foil; the extension of the other model is left rough, and when the articulating plates are made the models are set into their respective plates and the space at the back part filled with plaster. Partial models containing a number of teeth require no other antagonizer than a model made from a simple impression in wax of the lower teeth, which will fit the irregularities of the teeth of the upper model. Models for vulcanite may be coated with very dilute soluble glass (liquid silex), collodion, or tin foil. The late Prof. Austen, in 1858, sent his earliest experiments in rubber to Dr. Putnam, of New York, to be vulcanized. The Doctor wrote to know "what the varnish was which prevented the rubber from sticking." It was this soluble glass, used originally for the purpose of hardening the surface, to prevent injury from subsequent manipulations.

Antagonizing plates are made by molding a piece of gutta-percha over the model, kept very wet to prevent adhesions. The central part should be not less than one-eighth of an inch thick, to give stiffness to the plate; the rim on the edge should be the exact length of the teeth required and trimmed very carefully on the outside to give the proper fullness. The gutta-percha should be first worked into a ball, using from one to two sheets, according to the size of the mouth; then, pressing from the centre outward, the articulating rim is formed at the same time that the material is turned over the ridge. It is

quickly done, will not injure the most delicate ridge, and gives a plate as unyielding as any gold plate. In a lower set the rim may be stiffened with a piece of heavy iron or copper wire. In a full or nearly full upper set the impress of the lower teeth is to be received in a thin rim of wax set on the gutta-percha. In a double set the rims are trimmed till they touch uniformly, and then their relation marked by decided indentations across the line of contact. It is quite possible with these gutta-percha plates to take the articulation in every case with such absolute accuracy that no trial of the teeth is necessary, nor any grinding of the teeth upon inserting them in the mouth. Metallic articulating plates swaged for the case are much more troublesome and are no better. The usual method of making them of sheet gutta-percha, wax, or tin foil can never give one that full confidence in his articulation which enables him habitually to dispense with the trial of the piece after grinding. As vulcanite articulations are often taken, it would be as well simply to look at the mouth and guess at them.

The modeling composition is an excellent material for a base plate in securing the articulation. After being softened and adapted to the cast a roll of softened wax is placed upon the base plate over the alveolar ridge and shaped to the form of the arch. After being tried in the mouth and added to or trimmed off if too short or too long, the patient is directed to bite into the wax. To prevent securing too long or too short a bite, one or more small blocks of soft pine wood, about half an inch square and thicker than the required bite, may be attached to the base plate with melted wax and trimmed off until the necessary length is obtained. The wax rim is then applied over the block and the proper articulation secured. For an entire denture the articulating rims may be made of modeling composition.

Preparatory to the selection and grinding of teeth or blocks the thick articulating plates must be removed and the model covered with thin druggist's foil, and the space inside the ridge filled with a mass of soft wax pressed out until it meets the probable inside line of the teeth to be fitted; this affords a much firmer support to the teeth during grinding than the usual practice of using the thin wax or gutta-percha matrix plate. The top and outside of the ridge are left covered with foil alone. When blocks like Fig. 1122 are to be ground, passing over the front of ridge and surmounted with a rubber band, it is essential that the block shall not quite touch the model at any point; this contact is prevented by placing between the foil plate and the model a strip of foil having four, six, or eight thicknesses, as may be desired. But when blocks such as Figs. 1123 and 1124 or teeth like Fig. 1121 are ground resting directly upon the gum, with no rubber

above or under the upper part of the gum, the tin foil is retained only during the process of grinding, so as to receive the paint used in accurate fitting of blocks; the foil is then removed and the plaster scraped, so as to slightly bed the front blocks or teeth in the natural gums. As the teeth are ground they should be attached to the wax mass with softened or melted wax.

In grinding the greatest care must be taken to make close joints; but the fitting of the base requires none of the accuracy demanded in fitting gold plates, except when the tooth is to be set directly upon the gum. It is, however, a mistake to suppose that a space of half an inch can with perfect impunity be left between the teeth and plate; for vulcanite has a slight shrinkage on cooling. Unlike the shrinkage of metal, which is irresistible, that of vulcanite is controlled by the matrix, so that it results in no change in the shape of the plate. This is proved by the closeness with which it is seen to adhere to the model on opening the matrix. But it takes place in the direction of the

FIG. 1121.

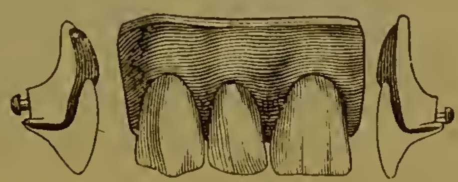

FIG. 1122.

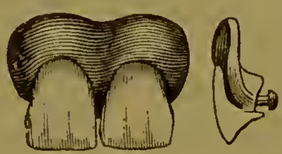

FIG. 1123.

FIG. 1124.

thickness of the plate. If, therefore, a large bulk of material is interposed between the teeth and ridge, it will shrink perceptibly either from the ridge or from the teeth; in the first case impairing the fit of the piece, in the latter case loosening the hold of the rubber upon the tooth. Thick masses of vulcanite are also apt to be porous or honeycombed, owing to the evolution of sulphur. That sulphur is evolved in all cases is evident from the staining of the plaster, blackening of the flasks and inside of the vulcanizer, and from the peculiar smell whenever there is escape of steam. We sometimes find it makes the rubber porous, especially in lower cases, in spite of every precaution taken to prevent it. It is not impossible that subsequent modifications in the time and manner of vulcanizing may correct this and several other difficulties attendant on the hardening of thick masses of rubber; meanwhile it is safer to avoid all unnecessary thickness of material. Many cases will permit the use of a stout aluminium wire behind and under the pins, running along the incisors and bicuspids; if so, it will

reduce the bulk of rubber and strengthen the piece. We often run a heavy platinum wire or strip of doubled plate behind the entire arch in lower sets to add to their weight and strengthen them; when carefully done it makes a very strong piece, and removes the objection of lightness which prevents the use of rubber in many lower cases.

When the teeth or blocks are ground, and the joints and outside fitting carefully examined with a Coddington lens or some other strong magnifying glass, the next point is to make guiding grooves or holes in the plaster articulator below the teeth; then place the lead band and pour the temporary investing rim, as has been already described in the investment of teeth for gold plate preparatory to backing (see p. 921). If it is a partial piece we often prefer to make this rim with a roll of gutta-percha, previously wetting the model to prevent its adhesion. An elastic band or string will hold this rim in place while the wax is being removed and substituted by the matrix plate, that is, the wax plate which is to be replaced by the rubber. The use of the rim permits an examination of the blocks or teeth on the inner side and the correction of any irregularity in the pins or in the inner edge of porcelain where it meets the rubber, also the grinding off of any point where a block may come unnecessarily near the model.

A small roll of soft wax is then to be pressed against the pins and model, holding the rim firmly to prevent the slightest displacement of the blocks. A wax matrix plate is then slightly softened and pressed gently over the face of the model and the other wax up to the tooth. Be careful not to thin the wax unequally, and yet to press it into all the natural irregularities of the model and to bring out the tracings of the rugæ and the central raphé. If the first wax is trimmed so as to just clear the tips of the pins and have a slight curve where it joins the model, very little trimming of the wax plate will be necessary when blocks are used. This method also enables the operator to know exactly the thickness of the plate at all points. Gutta-percha does not answer so well as wax, as it cannot so readily be smoothed where it joins the blocks. After using the wax-knife around the edges it is well to go over the surface with a strip of oiled buckskin.

The wax plate should vary in thickness from No. 14 to No. 18 gauge plate (Fig. 921), according to the depth of the palatine arch. Vulcanite cannot safely be reduced to the thinness of gold or aluminium plates, or even of the best stannic alloys. The elasticity of the best made vulcanite is often thought to justify great thinness of plate, and this may be allowed in some partial pieces; but in full sets, or where many teeth lie grouped together, elasticity, with thinness such as permits bending of the plate, is very apt to cause opening of joints or breaking of blocks. Elasticity of vulcanite lessens the

chance of injury from an accidental fall; but as an element of strength it is principally valuable as improving its rigidity and toughness; and the plate of all full sets should be thick enough to be unyielding under the force of mastication.

Fig. 1125 represents Dr. R. Wünsches' perforated metal plate, by

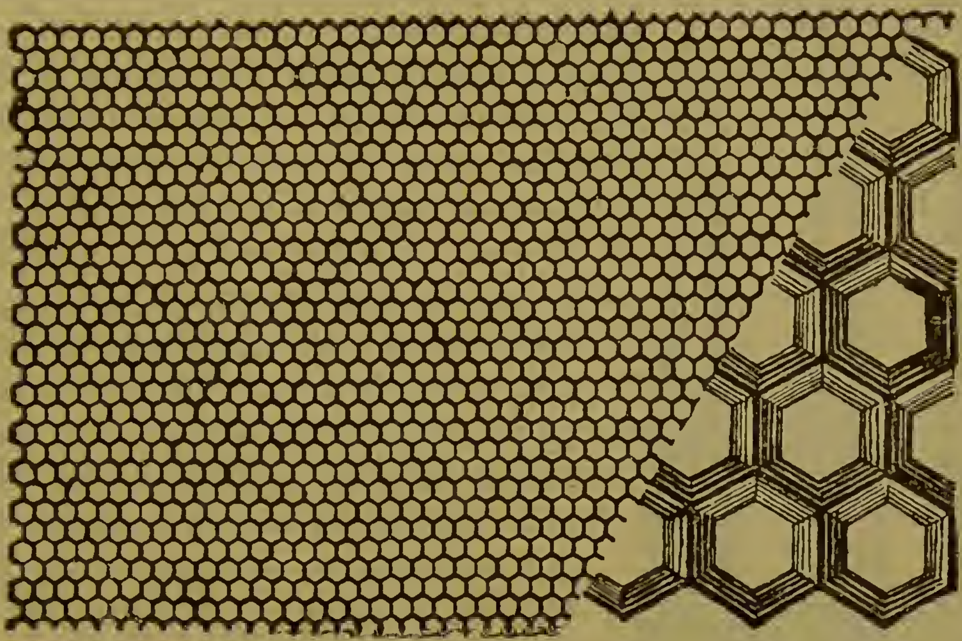

FIG. 1125.

the use of which, in combination with rubber, dental plates may be made much thinner than if made of rubber only. It is also claimed that these plates give additional strength; the holes in the plate are countersunk, forming a head or clinch on the face of the plate, and thus preventing any danger of detachment.

Fig. 1126 represents the ends of a suitable wax spatula or knife. In flowing wax with the heated spatula around the teeth, after they have been accurately arranged upon the model, care must be taken to keep the joints free of it; and the wax plate should be fashioned and smoothed with either the blowpipe flame, benzine applied on a piece of soft cloth, or by the repeated and careful application of the warm spatula.

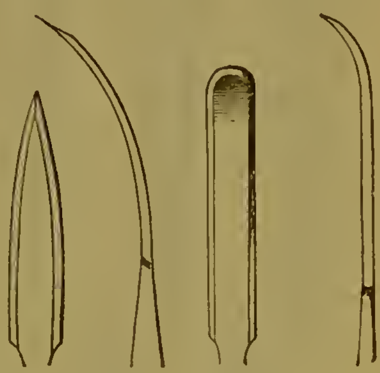

FIG. 1126.

The wax plate should be as perfect a counterpart of the vulcanite plate as it is possible to make it. Fig. 1127 represents a set of carving instruments, designed by Dr. W. W. Evans, for modeling wax in vulcanite, zylonite, and celluloid work.

When the inside wax plate has been completely finished the

outside plaster rim is removed, having provided for its easy removal by a break or section opposite the incisors. Again examine all joints with the glass to see that they have not been accidentally opened; then apply one or more strips of wax to give the required form of edge, outside the ridge and above the blocks. Plain or gum teeth or blocks, resting directly on the gum, must, of course, have no wax in front of incisors, canines, and first or even second bicuspids; in all such cases be careful, just before investing in the flask, to see that the teeth set closely down upon the model. Vulcanite blocks have a shoulder designed to receive the margin of the external rubber band; when the blocks have been chosen with such care that no grinding of the upper edge is necessary, this gives the best finish. But it often happens that the exigencies of the case require thinning or shortening of the blocks; a thin edge of wax should then slightly overlap the blocks. If the porcelain edge has sufficient thickness it is sometimes a good plan to bevel it; the rubber may then be finished continuously with the porcelain, and yet have a retaining edge. It is well to pass a very fine corundum slab over the gum just before placing the wax rim; it removes accidental roughness and makes the finishing process easier. Superfluous wax should be avoided outside as well as inside; but every undercut must be filled, else there will be danger of breaking thin or prominent ridges in separating the matrix. Outside surplus is more easily removed than inside: hence there is no objection to running the wax further up on the ridge than the finished plate; but unnecessary thickness is to be avoided for reasons before given.

FIG. 1127.

If the original model has been extended for articulation carefully remove the plate and saw off this portion of the model, and trim so as to fit the half flask in which it is to be set. This trimming done, replace the plate and fasten it around the edges with a hot wax-knife. It is now ready for the vulcanizing flask.

All forms of teeth may be used with the vulcanite base, and, unlike most other work, may be used again and again. Continuous-gum teeth can be strongly and handsomely arranged, provided the patient shows but little of the tooth; and also where celluloid is used in connection with vulcanite. Single teeth, plain or gum, require either to be backed with gold strips and soldered, or simply to have the pins lengthened. For this purpose heavy platina wire, say No. 20, should be cut into lengths from one-fourth to three fourths of an inch long, set between the pins in the required direction and soldered with pure gold. Plate teeth backed with a narrow platina strip, similar to Fig. 1128, may also be used, and are required in certain cases that will not admit of thick vulcanite teeth. The projecting tang strengthens the rubber in case of isolated teeth and may be serrated with a file; but a pair of

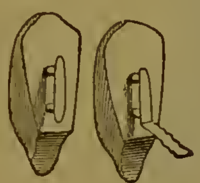

FIG. 1128.

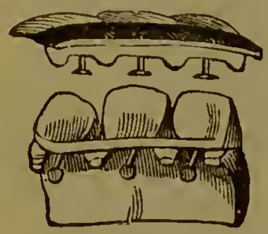

FIG. 1129.

forceps with serrated beaks may do this better and more quickly than the file. Occasionally some one or more under teeth strike so closely against the gum as almost to touch; if rubber is used in such cases these teeth must be plate teeth with the usual soldered gold backing, having a serrated extension into the rubber.

The assortment of vulcanite teeth now offered to the profession is, in variety of color, size, and shape, such as to meet almost every possible case. In fact, we doubt if the manufacturer's esthetic skill in making is not sometimes in advance of the dentist's esthetic taste in selecting. Certainly the stiff uniformity and monotonous expression which so frequently meet the eye is an injustice to the present high development of the dento-ceramic art. In the next chapter we shall illustrate by wood-cuts, kindly provided for us by the S. S. White Co., some of the delicate forms which so exactly imitate Nature. Figs. 1122, 1123, 1124, 1125, 1128, and 1129 will give a correct idea of the special form and shape of the ping of vulcanite teeth as at present manufactured.

Vulcanizers.—A sixteen-horse-power boiler, communicating by twenty feet of pipe with a thirty-inch cubical steam chest, was the vulcanizer of 1857.

The first one which was at all practicable as an office fixture was a two-chambered affair of cast iron, as large as a soda fountain reservoir, heated by a coal stove. Successive improvements have since been made, and the vulcanizer of to-day is a very different thing from the huge, clumsy affair from which it originated.

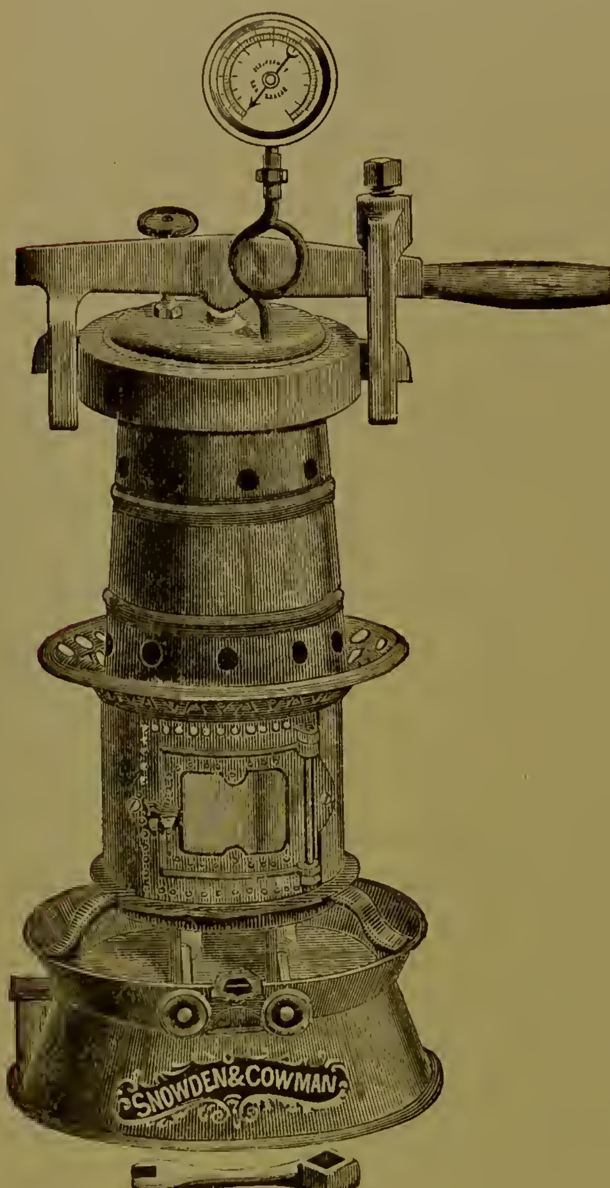

Fig. 1130.

The proper working of the vulcanizer and the satisfaction with which it is used depend, in a great measure, upon the perfection of the workmanship put upon it; and a saving of a dollar or two in first cost, coupled with the possession of a poorly-made machine, will prove an expensive investment in the long run.

Copper is now almost universally employed as the material from which the boiler or body of the vulcanizer is made, a ring of brass being brazed to the edge to form the packing joint and the attachment for the cover. The flexibility of these materials renders it important that the cover fastening should support the whole circumference of the edge of the boiler and bring the strain uniformly upon it in order to preserve the truth of the face of the packing joint. If the strain is brought to bear upon the circumference of the joint at intervals, the result is that the boiler gradually yields to the strains at the points where it is unsupported, the joint is drawn out of true, and in a short time the vulcanizer is leaky and comparatively worthless.

Figs. 1130, 1131, and 1132 represent the improved vulcanizers in use at the present time. Steam gauges are attached to the first two, and a thermometer to the other.

Fig. 1133 represents a dry steam vulcanizer for hardening vulcanite by dry steam, which, it is claimed, saves time and rubber, and gives to thin plates sufficient strength.

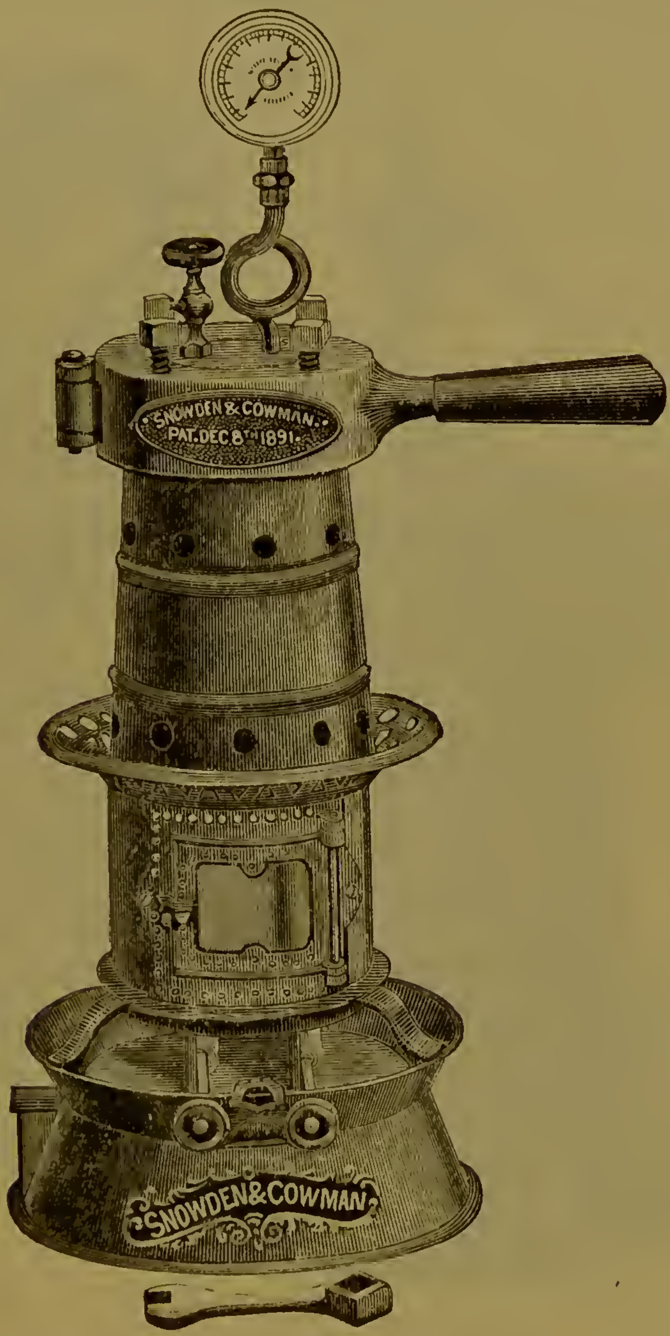

Fig. 1131.

The "New Mode Heater," Fig. 1134, invented by Dr. John S. Campbell, presents many points of difference when compared with other vulcanizers. It is made of phosphor-bronze, in a single casting, with two chambers, the one in which the flask is placed being surrounded by an outer steam-chamber. It has screws for closing the

flask as it is being heated, and is adapted to working celluloid as well as for vulcanizing rubber. Steam may be admitted to the vulcanizing chamber or not, as may be desired, and either "wet" or "dry" heat used. The use of the New Mode Heater, it is claimed, will prevent the rubber, when being vulcanized, from shrinking from the teeth, and also permit of the use of plain teeth with rubber for the base and celluloid for the gum, a form of work to which the name of "New

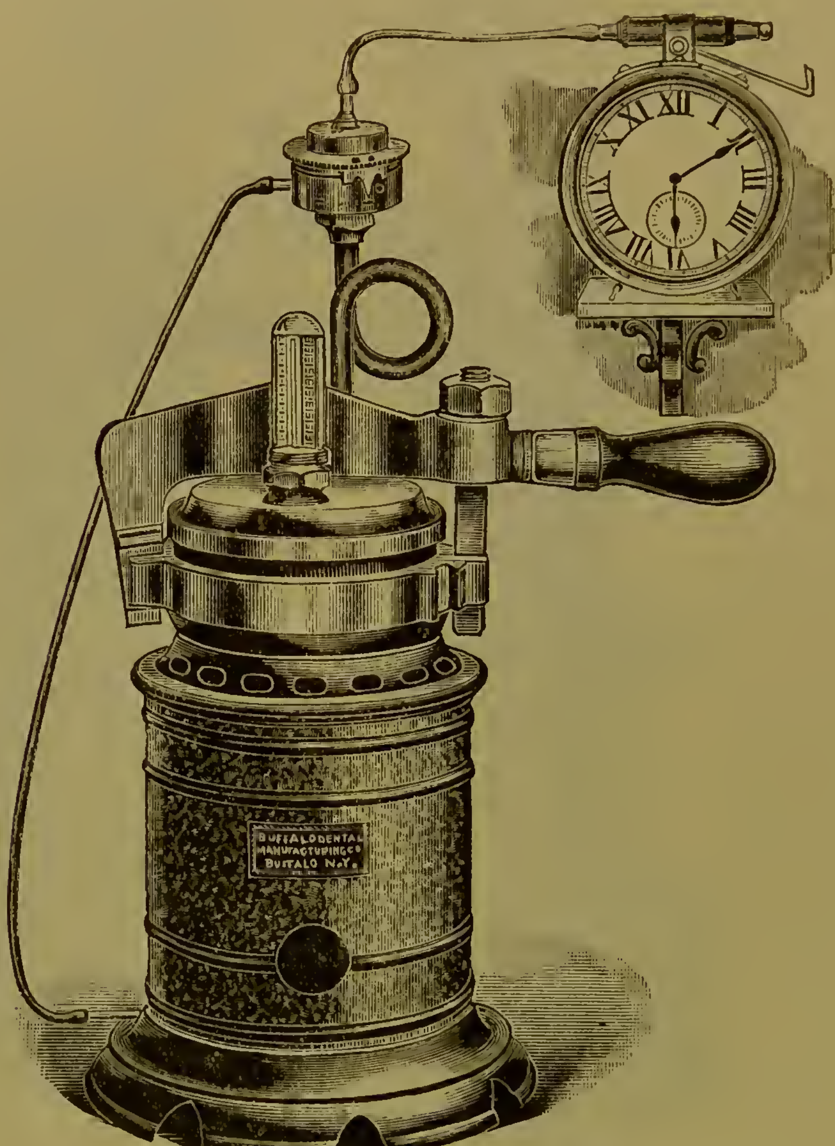

FIG. 1132.

Mode Continuous Gum" has been given by Dr. Campbell, the inventor (see Celluloid).

The vulcanizer is usually heated by either gas, alcohol, or kerosene. Gas, if used in a burner which will mix the proper quantity of air with it before burning is the most convenient, cleanest, and probably the cheapest fuel for the purpose. The flame should be a clear blue,

with no streaks of yellow. A yellow flame results from an insufficient mixture of air, and makes smoke, soot, and a bad smell from the production of acetylene. The use of gas also admits of the employment of the gas regulator (Fig. 1132), an attachment which automatically keeps the temperature of the vulcanizer at the exact point required. The steam pressure acts upon a valve to control the flow of gas to the burner, lessening the flow as the pressure rises and keeping it at the

FIG. 1133.

point for which it is set. It is not liable to get out of order and with it the supervision of the dentist over the vulcanizing process is not required ; and if the time cut-off is also used the dentist is at liberty to go to his patients in the operating room without the necessity of giving a thought to the vulcanizer, knowing that the temperature will be kept exactly right and that the gas will be turned off at the right time. The results will thus be uniform ; much more so than is possible

Fig. 1134.

with the use of the thermometer, as the regulator, operating by steam pressure, is more sensitive and exact than the thermometer can possibly be. After gas the alcohol flame is preferable for vulcanizing purposes. It is clean and inoffensive. Many use the kerosene stove, but taking into account its smoke and smell it may be doubted whether the economy secured by its use is not dearly bought.

The following tables, carefully collected from experiments of the French Academy, the Franklin Institute, Ure, Dalton, and others, will serve as a guide in the use of either the steam-guage or the mercurial thermometer:—

No. 1.					No. 2.	
Pressure per Square Inch.			Temperature.		Pounds.	Temperature.
Inches of Mercury.	Atmospheres.	Pounds Avoirdupois.	Scale Fahrenheit.	Differences.		
30	1	15	212°		63	300°
60	2	30	250°	38°	73	310°
90	3	45	275°	25°	80	315°
120	4	60	294°	19°	87	320°
150	5	75	309°	15°	95	325°
180	6	90	321°	12°	102	330°
210	7	105	332°	11°	110	335°
240	8	120	342°	10°	117	340°
270	9	135	352°	10°	124	345°
300	10	150	360°	8°	131	350°
360	12	180	374°	14°		
420	14	210	387°	13°		
480	16	240	398°	11°		
540	18	270	409°	11°		
600	20	300	419°	10°		
660	22	330	428°	9°		
720	24	360	436°	8°		

These tables show the increase of steam pressure with the temperature up to a point much higher than the dental vulcanizer should ever be called upon to bear. The second table is prepared especially to show the pressure due to the temperature at different vulcanizing points, and attention is especially called to the rapid increase of pressure with equal increments of heat as the temperature rises. The last column in Table No. 1 shows the additional temperature required for equal increments of pressure, and it will be seen that while it requires 38° to raise the pressure 15 pounds at 212°, only 4° is required for the same increase from 430°. The pressure nearly *doubles* with the addition of each 50° of heat, and allowing a vulcanizer to run up to 400° or 420° is shown to be a piece of unpardonable carelessness and a proceeding fraught with the greatest danger to life and property.

Every vulcanizer should be provided with some means by which the steam will be allowed to escape before the danger-point is reached. Safety-valves have been thoroughly tried and have proved unsatisfactory from their constant leakage. The fusible plug, consisting of an alloy of soft metal filling a hole in the vulcanizer, which would melt and blow out at 350° or 360°, was at one time much used, but it has the fatal defect of hardening after repeated heating, so that its melting point is raised to 400° or even more; so that after being used a short time it is wholly untrustworthy. A most satisfactory device for the purpose is the copper disc (Fig. 1135), made of metal thin enough to give way under an extreme pressure. It is secured upon the end of a small stud, screwed into the vulcanizer cap by means of a washer and screw-cap.

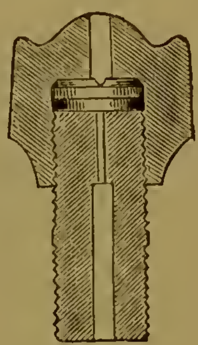

FIG. 1135.

Flasks.—Of flasks there are many varieties, made of iron and brass. The essentials of a good flask are: 1. It must have depth and width for the largest cases. 2. Both ends should be separate for greater convenience of placing the model in either ring. 3. The guide-fingers, about one-quarter of an inch long, should work straight and true, be strong, and yet not unnecessarily break the regularity of inside and outside surfaces; cover flanges may be very short. 4. Inside and outside should present as unbroken a surface as possible for facility in removing and cleaning off surplus plaster. Both rings should taper, partly to give greatest breadth to the line of junction, partly for easier delivery of plaster.

Figs. 1136 and 1137 represent the "Star" and "Anchor" flasks, the first being reversible; other flasks are also self-locking by means of flat springs on the outside of the lugs.

Fig. 1138 represents the "box flask," designed for extra large cases, splints for fractures, artificial palates, etc.

Making Matrix, Removing Wax, and Packing the Rubber.—The model of a full set is placed in the shallow half, A, of the flask (Fig. 1139), with wax plate and teeth attached, as before described. The model must be saturated with water, to prevent the too rapid setting of the plaster batter with which the flask is partly filled, and which, on placing the model, rises to the edge of flask and edge of the wax plate. The plaster should be mixed as thick as will pour readily and the lower section of the flask partly filled with it, when the model and

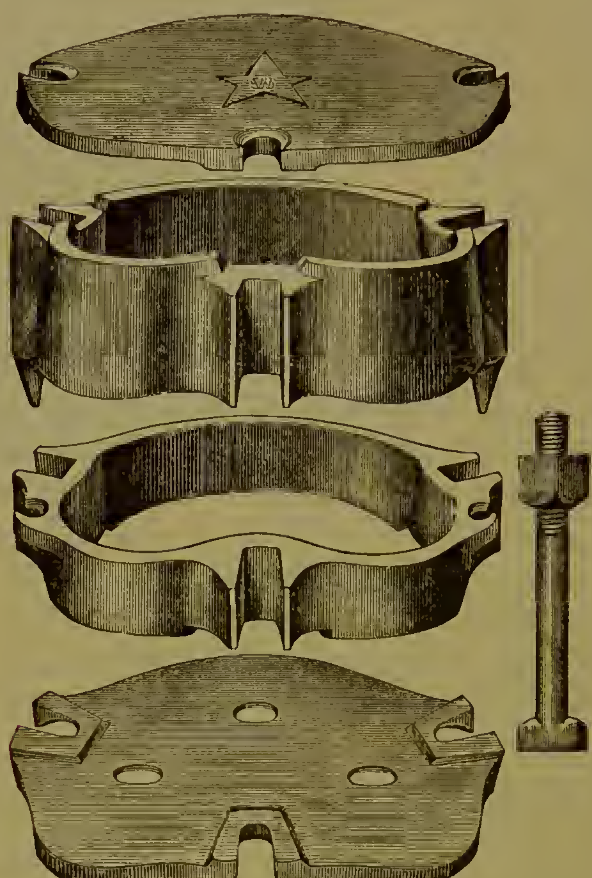

FIG. 1136.

teeth should be placed in it, bottom down, as shown in Fig. 1139, A, and slightly inclining in front so as to exclude all air bubbles when forcing it into place. In the case of an entire upper or lower set the plaster should extend up to the wax, as this will allow the teeth to be imbedded in the plaster filling the upper section of the flask. As soon as the plaster has become moderately firm trim smoothly up to the model with spatula or sponge; then soap this surface, or varnish and oil it, or cover it with tin foil. When shellac varnish is used, care should be taken that the teeth or gums are not coated with it.

Some prefer the soap solution, white soap, ℥j, soft water, Oj, for separating plaster surfaces. Some are in the habit of placing the lower

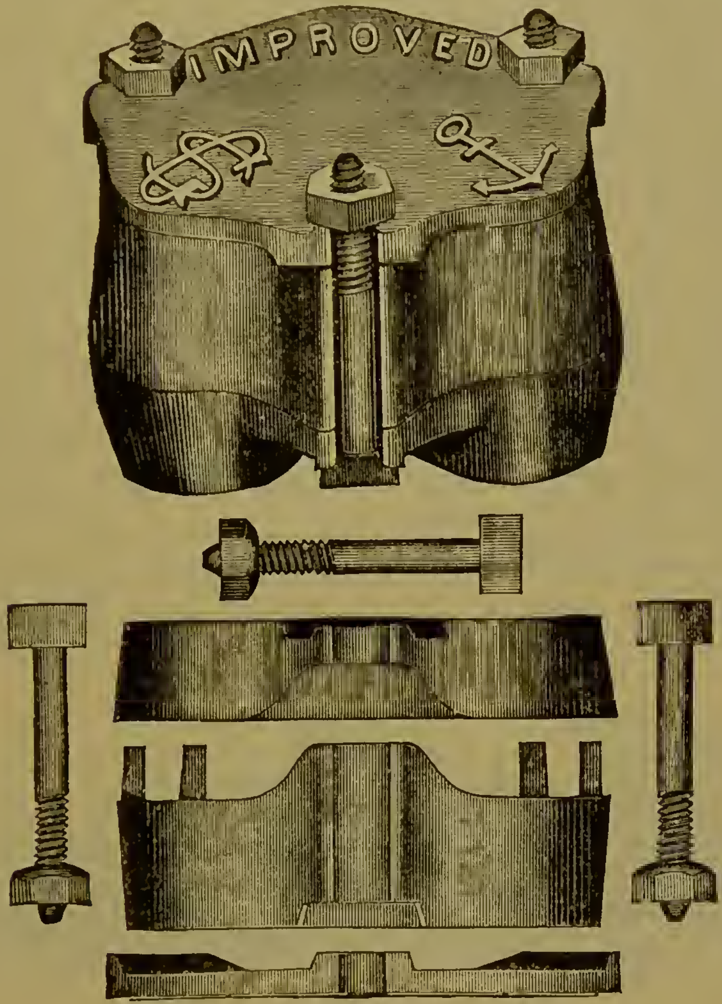

Fig. 1137.

Fig. 1138.

half of the flask in water, that it may absorb as much as possible before the upper half is poured. Mix a fresh lot of rather stiff batter, and brush it carefully over the wax and into all the interstices of the teeth. Then place the upper half-flask, C, accurately upon the lower half, and quickly pour the batter, stirring it well with a feather or small brush, into the space between the teeth and sides of the flask. Set on the cover D and apply the clamp B, or a heavy weight. Before it fully hardens wash off the plaster with a sponge from the outside of the flask, and let it get quite hard before separating the two halves. The object of making the batter stiff is to give it greater hardness for support of the blocks under pressure of packing. These are often displaced and the joints opened under moderate pressure; because, first, the batter is too thin, and, secondly, time is not allowed for it properly to harden before packing. The flask should be set in water at about 120° for five minutes before separation, so that in case of undercut or of a thin or prominent ridge there shall be no danger of breaking the model. Dry heat may also be used to separate the flask, but

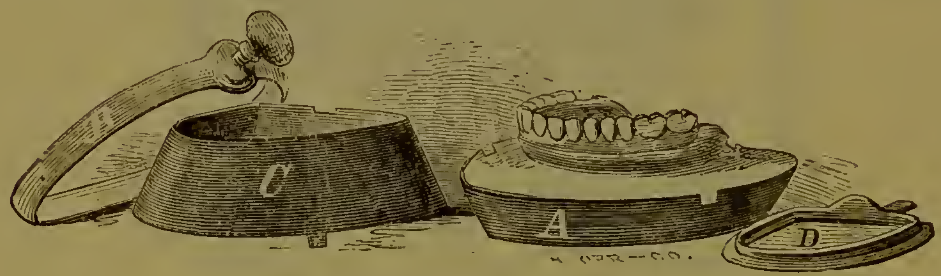

FIG. 1139.

the wet is preferable, as the former may melt the wax and cause it to be absorbed by the plaster; and if the base plate is gutta-percha it will, if made too hot, adhere to the model. The wax or gutta-percha model plate should be removed entire if possible, and also the wax around the pins, by means of a small excavator, and what remains may be washed away by pouring over the surface a stream of boiling water from a height of about one foot. All wax should be carefully removed in order to prevent deterioration of the rubber, and as much of it as possible be preserved for the purpose of determining the quantity of rubber necessary to use in packing the piece. After the wax is entirely removed vents or gates are cut in the plaster surface of the investments, as shown in Fig. 1143, to allow the excess of rubber to escape when the flask is closed. The flask will then present the appearance shown in Fig. 1140; the model-half, E, separating from the teeth and wax contained in the dental-half, H. Should the joints not be very closely fitted, place a little dry plaster over each and touch with a drop of water or diluted soluble glass, and when hard trim off

the surplus plaster. Some prefer to pack with tin or gold foil. The zinc cement in the form of the oxychlorid or oxyphosphate is also serviceable, and when used for such a purpose should be mixed quite thin and allowed to become as hard as possible. Without some such precaution the rubber will press into open joints and present an unsightly appearance; of course, closely-ground joints are preferable to any of these expedients; but neither the tightest joints nor any precautions will avail if strong pressure is used in packing, for this invariably opens the joints and admits the gum.

In partial cases, or where no vulcanite is required outside the arch and above the teeth (where plain teeth are used, resting directly upon the gum), the deep half, H, must be used for the model and the line of separation be made at the cutting-edges of the teeth, so that the plaster around the teeth may come nearly or quite level with the edge of the flask. The teeth are thus firmly fixed in their exact position and resist displacement, which the separation of the flasks or the pressure of the rubber might possibly occasion. In this way, should

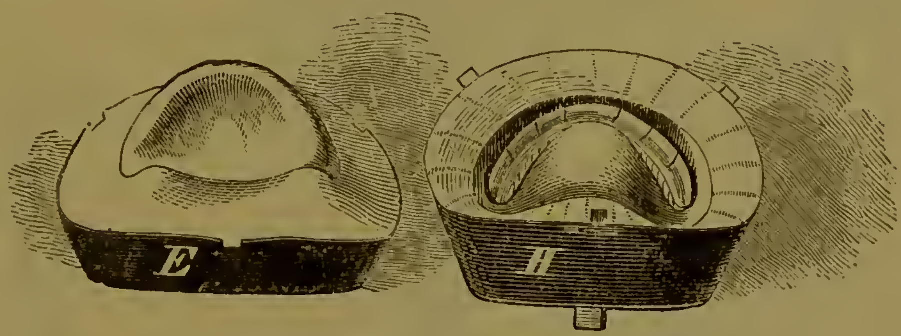

FIG. 1140.

the flasks chance not to come perfectly together, the result will be an extra thickness of plate, but no displacement of teeth. We consider this use of the deep-half of the flask in all partial cases as of the utmost importance. The teeth are never disturbed in their position on the model given them in the wax plate; also, there is no breaking of plaster teeth or splitting of the model by pressure of the rubber.

To prevent the rubber from adhering to the surface of the plaster model and mold, which gives a rough surface to the palatine portion of the plate, this surface, as before remarked, should be coated with either liquid silex, collodion, or tin foil. When liquid silex is used, a thin coat upon a moist plaster surface answers best; collodion is applied like liquid silex; tin foil is attached to the plaster surface by means of shellac varnish and carefully adapted by pressure with a soft cone of leather to all the inequalities, and its surface is coated with collodion, which is allowed to dry, when it is again coated with the soap solution. Such a method will render it easy to remove the tin

from the vulcanized rubber and give a polished surface. Without such precaution the use of muriatic acid may be necessary in order to remove the tin foil. Gilding the surface of the model with gold foil is also done.

Clean hands and instruments are very necessary in packing rubber, otherwise the color and even the texture of this material are impaired. The mold as well as the rubber should be warm during the packing process, and the latter should be cut in different sized pieces, using a large piece of the proper shape to cover the palatine surface of the model, and which may be applied by pressure with the thumb and fingers, first dipping them in water. Fig. 1141 represents a boiler suitable for heating the flasks, and having a flat top on which the rubber may be softened. In packing the smaller pieces of rubber,

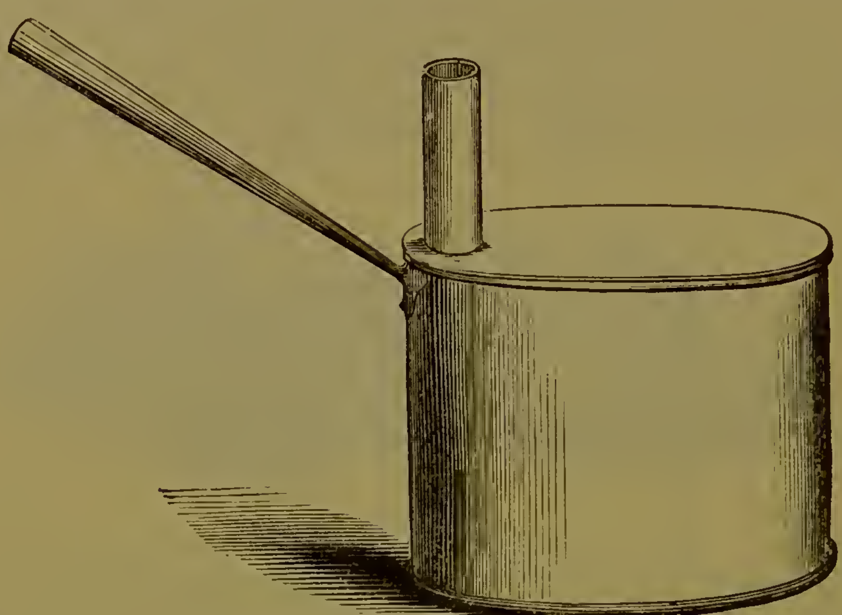

FIG. 1141.

and especially the long strips suitable for the rim of the plate, care is necessary that all particles of plaster be excluded, and also that too much rubber is not pressed against thin margins of the gum; otherwise fracture of the porcelain blocks may result when the flask is being closed. It is safer to pack the rubber thicker in the center, and as it yields to the pressure it will flow around weak points without danger of fracturing them. Each piece of rubber as it is added should be consolidated; and if any tooth or block has become loosened in the plaster a drop of liquid silex placed in the bottom of its plaster cavity will, after it becomes dry, hold it firmly in place.

It is desirable in all cases and quite essential in most that the flasks should come perfectly together. This is accomplished by attention to three points: 1. Softening the rubber; 2. Using a proper quan-

tity; 3. Having vents for the surplus. First, for softening the rubber use a deep, covered saucepan capable of holding the flask-press and containing two or three inches of water. When the flask is thoroughly heated by the steam, the rubber is placed over the cover of the saucepan or on a small shelf attached to the inside of the saucepan; then while soft let it be packed with the help of a pointed stick or the smooth end of a straight excavator flattened for the purpose into the dental half of the matrix. Around the teeth the rubber may be packed in the form of very narrow strips, somewhat as foil is inserted into the cavity of a tooth, with instruments made from excavators with blunt points bent at a right angle. The remainder is packed either in large strips or in one piece cut to the shape of the wax plate.

Secondly. It is important to use the proper quantity of rubber; too little vulcanite spoils the piece; too much requires a pressure which may break the blocks, displace the teeth, and force rubber into the joints, or else requires a long time for a safe degree of pressure to bring the flask together. In some cases the quantity can be correctly found by having the sheets of vulcanite exactly as thick as the wax plate, removing the latter as carefully as possible, and marking off its size on the former. But for some irregularly-shaped cases and most lower cases the following simple method will be found better. Let the plate be entirely of wax; remove it all from the matrix and roll it into a sheet the thickness of the rubber; make the rubber a little larger than the wax; then cut into conveniently-

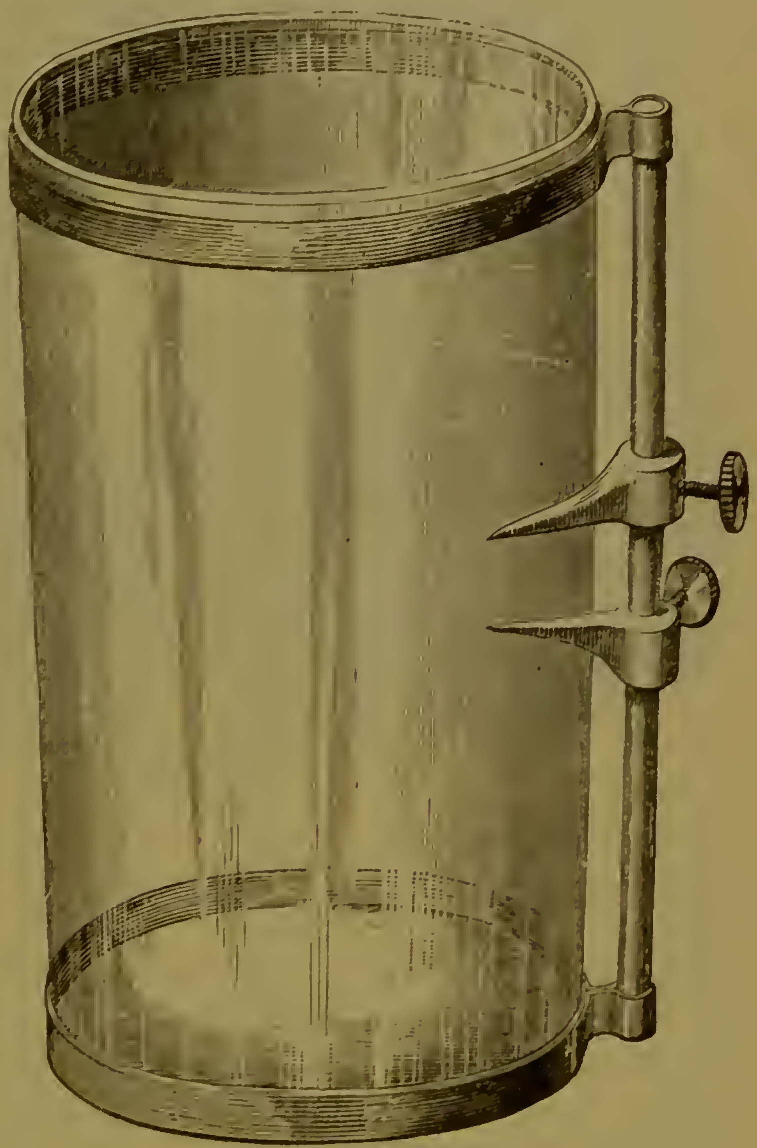

FIG. 1142.

sized strips and pack, putting most at those points where the wax was thickest. Starr's measuring glass, which determines the quantity of rubber by "displacement," is a convenient instrument for this purpose. (Fig. 1142.)

For ascertaining the quantity of rubber required for any given case: The vessel being about half filled with water, set the lower pointer to the level of the water; throw in every particle of the model plate; set the upper pointer to the rise of the water; empty the vessel and again fill with water to the lower pointer; add a sufficient quantity of rubber to cause the water to rise to the upper pointer and there will

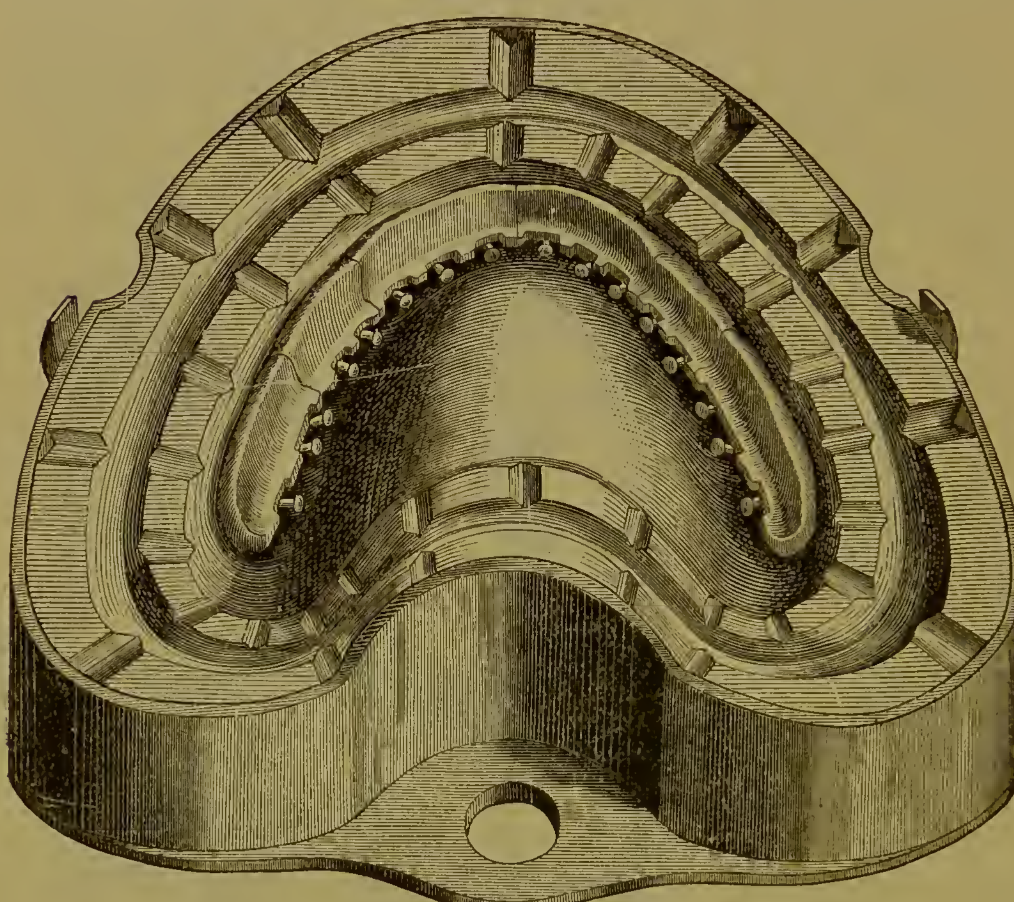

Fig. 1143.

be just enough to fill the mold. Allowance can then be made for surplus.

Thirdly. Since the error in quantity should always be on the safe side of excess, provision must be made for the escape of this surplus by cutting vents, that the halves of the matrix may come together without too great pressure. Fig. 1143, taken from Prof. Wildman's monograph, is a fine illustration of the best method of cutting these vents. The radiating vents might, however, stop at the circular groove, taking care to make this large enough for any possible excess

of rubber. If these leaders are too large next the plate the rubber may not pack so firmly as is desirable; also the generation of gas while vulcanizing may force rubber too freely into the groove, and so make it porous.

A good form of flask press is that of Messrs. Snowden and Cowman, Fig. 1144. As soon as the rubber is packed the halves of the flask are carefully brought together, placed in the press, and a moderate force applied; the press and flask are then placed in the heater. A piece of pure "rubber-packing," about an inch thick, placed under the screw, will, as before stated, insure a constantly acting force whilst in the heater. Avoid using the full power of even one hand

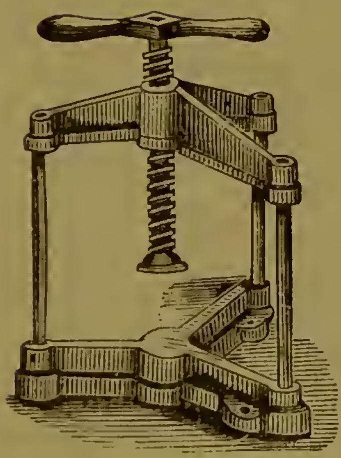

FIG. 1144.

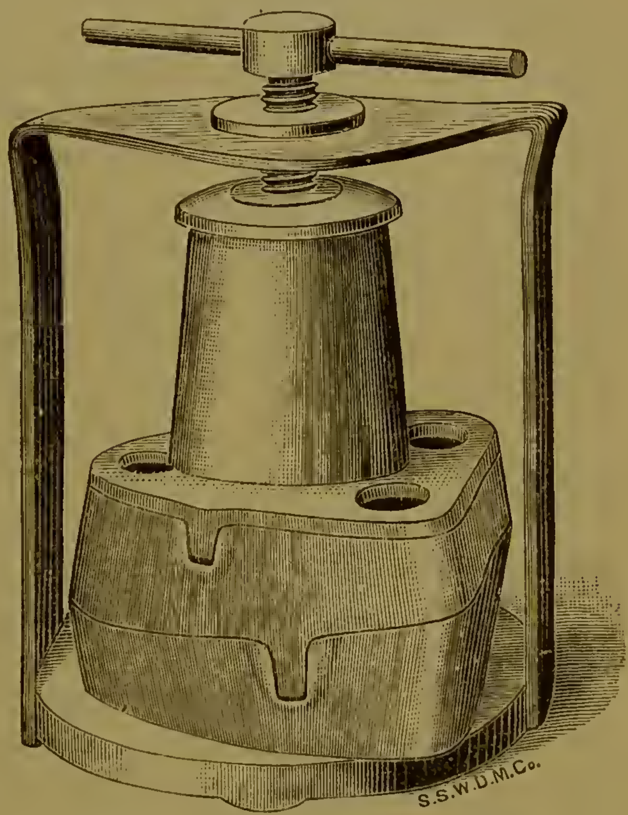

FIG. 1145.

upon the lever; if the vents are free and great excess of material is avoided, moderate pressure acting steadily in the heater will safely bring any flask together in from ten to forty minutes.

Fig. 1145 represents Dr. Donham's Spring Clamp, which utilizes the tension of a spring for closing the flasks in vulcanizing. It gives continuous pressure and dispenses with flask-bolts.

In all cases use a flask press first and the small screw bolts, except in the Donham clamp, when the case is ready for the vulcanizer. If pressure is applied suddenly, before the rubber is sufficiently plastic, there is great danger of fracturing the teeth, especially sectional blocks. When the screw bolts alone are used to bring the sections of the flask

together, no more pressure should be applied at first than can be made with the fingers, after which the flask is placed in boiling water for a few minutes, when a gentle turning of the screws will suffice to bring the parts together. Clean flasks are essential to successful packing, for soiled fingers stain the rubber, which interferes with perfect union of the pieces; hence all apparatus handled in packing should be so simple in form as to be readily cleaned; also, it is well to keep them constantly covered with a coating of varnish.

Dr. T. F. Chupein, referring to some valuable suggestions of Dr. Geo. B. Snow concerning the Physical Properties of Vulcanite, says: *—

"The writer, after giving many good points and making many valuable suggestions about vulcanite work and the behavior of vulcanite dental plates, recommends that when from the nature of the case it is found impracticable to make the plate of equal thickness, the places where the plate will be unduly thick be filled with small pieces of rubber which has been already vulcanized (an old rubber plate, for example, cut up and cleanly filed into small pieces about the size of duck-shot), to compensate for the undue thickness of the plate at these points and to control the expansion or contraction of the material.

"If a set of teeth be waxed up and flasked in the usual way, it will be extremely difficult to know where to place these pieces of vulcanized rubber; the memory being the only guide as to where they are to be put, the procedure is reduced to guesswork.

"To overcome this difficulty (recognizing the value of the suggestion) we proceed as follows: After the case has been waxed up as usual, whether gum section or plain teeth are used, the wax is carefully removed from the front part of the sections or from the front part of the plain teeth, so that these are held in place only by the wax on the palatal surface. Those parts of the sections or plain teeth and the plaster model are then painted with rubber solution (red rubber dissolved in chloroform), and when this dries small pieces of red rubber are packed next the sections to form the rim; or small pieces of pink rubber are packed next the plain teeth to form an imitation of the gum. This being done, the case is flasked so that the plaster of investment is brought all over the front part of the teeth as shown in the figure. Thus the small pieces of vulcanized rubber may be placed just where they are needed to compensate for the extra thickness or volume of rubber at these points.

"Fig. 1146 indicates the extent of such extra thickness under the

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* Physical Properties of Vulcanite, *Dental Cosmos*, Aug. No., 1888.

bicuspids and molars, for which spaces the vulcanized pieces are to be prepared in the present instance.

"Incidentally it may be observed that by this mode of flasking the teeth are kept in their exact positions relatively to the cast, and, the gates being freely cut in the other part of the flask, the articulation will be found undisturbed even though the flask should not have been accurately and completely closed.

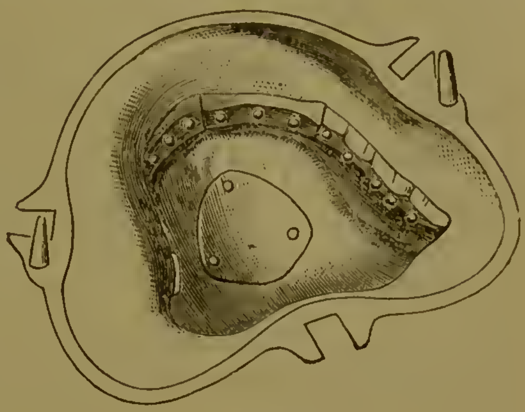


FIG. 1146.

"It is well to say that in removing the wax from the front part of the case this should be all removed before the case is painted with rubber solution, and the small pieces of red or pink vulcanite that are put in place of the wax that was removed should be added to the painted surface with a clean wax spatula, free from all grease, wax, or dirt, and heated (for easier manipulation of these pieces) in the blaze of a spirit-lamp. If there is any grease on the spatula the rubber will not stick to the places where it is wanted."

Time of Vulcanizing.—When the halves of the flask are brought into contact it is taken from the press, the screws are adjusted, and it is placed in the vulcanizer, which is then filled two-thirds full of boiling water, the cover adjusted, the gas or lamp lighted, and time reckoned from the moment of closing the cover.

The time occupied in heating up and vulcanizing varies with different varieties of rubber from fifteen minutes to an hour and a half. As thermometers vary much, and the rubber used also varies, the best plan is for every one to vulcanize trial pieces until the required hardness, toughness, and elasticity are obtained. It should curl under the scraper like horn, permit bending at an angle of at least 45°, and return to its original shape unchanged.

When the heat is too great, or the time too long, the rubber becomes dark and brittle. For the black rubber a longer time is necessary than for the red rubber, and the best method is to heat up very slowly unti it has reached 320° F., or to use a less heat and longer time. The more foreign matters rubber contains the less time is required to vulcanize it; and where the adulteration is considerable, as in the case of the pink rubber, the heat may be raised more rapidly, but such rubbers are weak and unfit for forming any more of the plate than the gum portion. In using the red rubbers the heat should not rise higher than 320°, and the piece should be allowed to stand until it is cold.

In a very large proportion of vulcanite pieces the full strength of the material is lost by overheating; in others by the opposite error of giving too much elasticity and throwing undue strain in full cases upon the blocks and the rim of rubber behind them. If some of the time spent in polishing up vulcanite and bringing out the offensively glaring brilliancy of its color were devoted to careful management of the vulcanizer, to making proper record of heatings, so as to arrive at uniform results, and to the cultivation of those habits of accuracy which alone can give success, there would be fewer broken pieces returned to the laboratory for repair.

Slow heating and a perfectly tight vulcanizer full of water, with flask well bound together and vents not too free, are the best safeguards against porous rubber, except where an unusual thickness is required, when the small pieces of hard vulcanite may be used in packing.

It sometimes happens, when large and thick masses are built upon the plate, as in cases of excessive absorption, that the thick portions of the plate, when vulcanized, prove to be soft and spongy in the center. This is the result, first, of bringing the plate up to the vulcanizing point too quickly and the retention of the sulphurous gas. A long time, even two, three, or four hours, the time depending upon the thickness of the mass of rubber to be hardened, should be taken to raise the temperature of the vulcanizer from, say 250° to 320°, if no pieces of hard rubber are used in packing. Second. Different samples of rubber act differently when vulcanized in thick masses, depending somewhat upon the amount of earthy matter contained in them. It is very difficult to vulcanize a mass of pure rubber and sulphur even three-eighths of an inch thick and insure its solidity. On the other hand, some of the English pink rubbers, which contain large amounts of oxid of zinc and vermilion, can be vulcanized in thick masses with but little trouble. It is to be remarked, also, that rubbers which are "loaded" with earthy matter have less shrinkage than those which are purer.

So the expedient may be resorted to of packing the inside of thick portions of the plate with some one of the rubbers containing more earthy matter than those usually employed, or using the same pieces of hard vulcanite as before described. The expedient of filling in parts of the mold where the thickness of rubber is excessive with a mixture of small fragments of old vulcanite and new rubber will answer every purpose as a safeguard against porosity. If the pieces are freshly filed all over their adhesion with the new material will be perfect, and the plate will be as strong as though wholly of new material.

There seems to be a point beyond which, if rubber twice passes,

it becomes inevitably brittle; hence no confidence can be placed in the old material of a repaired piece. Two flasks in the same vulcanizer cannot give the same results; loss of heat by radiation is greatest from the cover, and the supply of heat is from below; hence, necessarily, the lower half of the oven is hotter than the upper. Uniformity of texture can be obtained, therefore, only by vulcanizing one piece at a time. One who is systematic in the arrangement of his work will separately vulcanize the pieces of a double set in very nearly the same time required if both are done at once; for one piece may be in the oven while the other is in preparation for it.

Removal from Vulcanizer and Finishing.—Upon expiration of the time determined upon the flame is to be at once extinguished; the vulcanizer may be cooled gradually as it stands, or rapidly by the escape of the steam, or by setting the lower three-fourths of the vulcanizer in cold water. The last method of rapid cooling is preferable, running the heat five minutes longer than when slow cooling is practiced. Letting off steam is a very disagreeable process and makes the plaster of the flasks very hard to cut out. Flasks may, with perfect safety, be cooled by setting the vulcanizer containing them in snow or pounded ice if desired; but in no case should the flasks themselves be cooled by contact with cold water, as some might chance to penetrate to the blocks and crack them. The flask should be opened and the piece removed from its plaster investment within two or three hours after vulcanizing. After that time the plaster assumes a sand-like, granular state, and adheres with great tenacity to the plate, no matter what separating varnish may be used. Tapping the edges of the flask after separation will dislodge their contents in mass; the plaster can then be trimmed from the piece, taking care that it is perfectly cold. The adherent plaster in the dental half of the flask can easily be washed from the piece with a stiff brush; but the model half leaves a coating that clings very tenaciously, unless means are taken to prevent it; soluble glass, a dilute ethereal solution of collodion, or a layer of thin foil have been already mentioned as the proper preventives.

The process of finishing is more troublesome than in the case of gold work, unless great care is used in the formation of the wax plate. Several sizes of round and half-round files are necessary for finishing up the edges and convex surfaces; for the concave surfaces, scrapers, graving chisels, and curved files. Fig. 1147 represents common forms of rubber files.

Fig. 1148 represents several sizes of a form of scraper or finisher, suggested by Dr. Kingsley, with convex back and thin edges, which do not dull readily and are easily sharpened.

Lathe burs and file-cut wheels will be found very useful if there is to be much reduction of thickness—Figs. 1149 and 1150 represent one of each—the burs in sets of four and the wheels in sets of three.

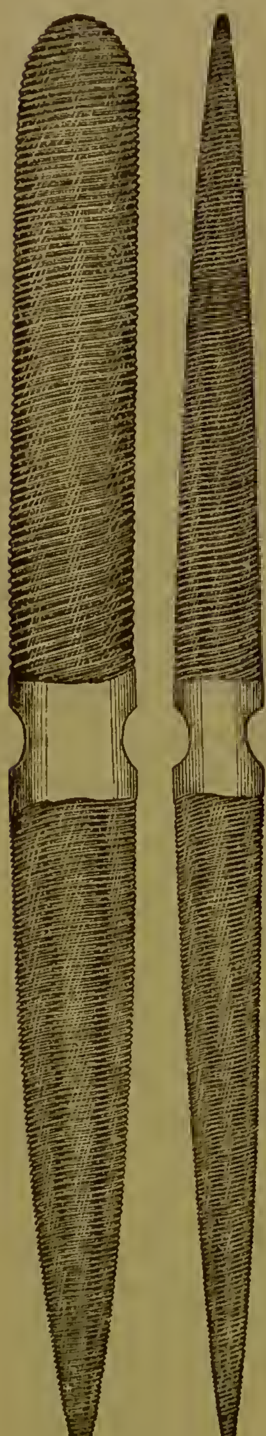


Fig. 1148.

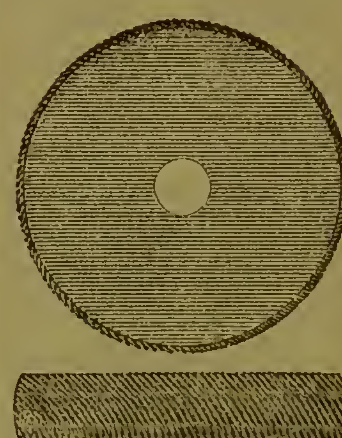


Fig. 1149.

Fig. 1147.

Fig. 1150.

Sufficient thickness must be left in the body of the plate for strength, but the edges should be chamfered off. A pair of calipers (Figs. 1109.

1110) are required to measure the thickness of the plate if it is to be reduced by files and scrapers, and the use of this instrument will lessen the danger of cutting through the plate. Some operators next use sand-paper or emery cloth ; others use pumice stone on cork wheels ; many prefer Scotch stone. The third step is the use of rotten stone (not Tripoli, which cuts with too keen a grit), either on a brush wheel with tallow or oil, which is the more rapid process, or on a stick of some hard wood, with water, which is the more cleanly. A little oxid of zinc on a soft wheel or on the finger will give a brilliant finishing polish, but is not essential, as the rotten stone can be made to polish very highly. After trying the piece and finding that no part of the edge requires alteration, a bright surface color may be given by placing the piece in alcohol and exposing to the sun's rays for six or twelve hours. Some regard this as an improvement ; it certainly does not injure the quality of the plate, but the original mahogany color of the vulcanite is in much better taste than the bright vermilion tint thus given. In finishing partial cases it will prevent accident if, after filling the edges, plaster, or modeling composition, or gutta-percha is fitted to the palatine surface of the plate ; the subsequent operations can be conducted more rapidly and with less danger in delicately shaped pieces. Vulcanite is softened by heat ; hence a piece is sometimes bent by revolving the brush-wheel too rapidly. A piece that has been in any way bent or warped may be restored by heating either in boiling salt water or in oil to about 250°. While soft it may be bent with the fingers ; but as this guess-work method is hazardous it is much better to bind it down upon a model and heat to the point of softening.

By pouring plaster upon the palatal surfaces of thin partial plates and allowing it to harden, the danger of changing the shape when polishing with a revolving wheel is avoided. To give a polished surface to a vulcanite plate and dispense with the usual finishing up and polishing process, the surface of the wax may be covered with tin foil, which is lightly but smoothly burnished to the surface of the wax. To insure a polished surface to the palatal surface of a vulcanite plate also the surface of the model may be varnished with shellac and then covered with tin foil, evenly applied ; but a better method is to obtain a block tin or other suitable metal die from the plaster model and vulcanize upon it. When tin foil is applied to the surface of a wax plate all the wax may be removed without injury to the foil by pouring boiling water upon it. By the use of the improved heaters to vulcanize rubber, although a longer time is necessary than with the common vulcanizers, yet the strength and color of rubber so manipulated are improved. To vulcanize red rubber with these heaters the flask may

be heated and packed in the oven; and when this process is completed the machine is closed, and the steam valve is then raised to admit the steam to the packing chamber. When the heat has been raised to 320° the case is allowed to remain in the hot box at that temperature for one and a half hours.

To produce a pure jet-black rubber plate, perfectly pure black rubber should be used, and vulcanized by the *dry* process. The model and investment should be thoroughly dried before packing the black rubber, and no steam be allowed to enter the packing chamber during the operation. The time required for vulcanizing black rubber by the *dry* process is five hours at 320°. To construct a vulcanized set with a celluloid gum, see chapter on Celluloid.

A modification of the vulcanite process was patented in 1868 by Dr. Stuck. Briefly described, it is the vulcanizing of rubber between two polished tin-foil plates, the articulating plate being formed upon a block-tin model made directly from the impression. The plate comes out highly polished, provided the tin foil has been carefully burnished into shape. On the palatine surface this polish is objectionable; hence we should prefer to vulcanize directly upon the block-tin model, the granulated surface of which is better for adhesion. The plate, thus made smaller than the mouth by the shrinkage of the tin, would in most cases fit better; the difficulty is in removing the finished plate from the metal in case of a deep arch or slight undercut, an objection, however, which is now overcome by using shell or sectional tin models. A second peculiarity of Dr. Stuck's plates is their elasticity, compared with pieces as ordinarily prepared and vulcanized in the same oven. This, we suggest, is due to the retention of the sulphur by the foil plates on either side. We think these elastic plates are usually made too thin, under the idea that elasticity, like rigidity, compensates for diminished thickness. This method, though open to some objection, is worthy of careful investigation by every worker in vulcanite.

It sometimes happens that the rubber shrinks from the teeth, leaving a space in which particles of food and saliva collect. The cause of such shrinkage has been ascribed to the fact that the rubber in cooling from a temperature of 320° to that of the atmosphere, contracts more than any metal, and the plaster of the model and investment after boiling in sulphuretted-hydrogen water for sixty minutes is rendered very soft, and has not strength sufficient to hold the vulcanite in form while cooling; but, on the contrary, yielding to pressure, allows the rubber to draw away from the teeth. It is claimed that any method which will prevent the plaster model and investment from becoming soft will overcome this objection.

Repairing and Refitting Plates.—Vulcanite work may be repaired by removing the broken tooth or block, cutting dovetails in the rubber, and then fitting the new teeth, arranging the wax, and vulcanizing as at first. To describe this method of repairing more in detail: if a tooth or block has been broken the fractured parts should be removed and a dovetail or groove formed in the base covering the space occupied by the tooth to be replaced. The tooth or block is then fitted by grinding and supported by wax, the dovetail being also filled up rather fuller than is necessary to restore the surface in order to allow for finishing. All of the set, except the portion of the lingual surface over the wax, is then imbedded in the lower half of the flask, and the plaster surface varnished and oiled to prevent adhesion when the upper section of the flask is adjusted and filled with the plaster investment. When the plaster has set and the two halves of the flask are separated, all of the wax is removed, the piece heated up, and rubber packed into the cavity around the tooth or block. The sections of the flask are then heated and screwed together and the process of vulcanizing completed. Another method of repairing rubber plates, and by which pressure is avoided, is to first cleanse the piece thoroughly, and to coat the inner surface with a little oil to prevent the plaster which is poured upon this surface in order to form a new model from adhering. When the plate is separated from the model dovetails are cut into the plate, and it is returned to the model and the teeth adjusted by grinding, after which the surface under them is coated with the rubber solder or liquid rubber, as are also such parts of the teeth and pins that are to come in contact with the rubber. The teeth being replaced, warm rubber is packed under them and into the dovetails, and the case is then invested in one mass of plaster, no flasks being used, and vulcanized in the ordinary manner. Where the plate is cracked or broken into two pieces the parts should be carefully adjusted and secured in place by either wax or ligatures and covered with plaster on its inner surface so as to form a model. The plate is removed from the plaster when it has set and a groove cut out the entire length of the crack or fracture, on either side of which dovetails are formed. When the pieces are returned to the model, the case is placed in the lower half of the flask and invested with plaster, all portions of the plate being covered except where the new rubber is to be packed. The rubber solder is then applied to the prepared surface and the rubber packed firmly into the groove and dovetails. The upper half of the flask is then adjusted and the investment completed, when the case is ready for vulcanizing. Instead of cutting dovetails, which are often disfiguring and sometimes impracticable, a liquid preparation may be used known as Rubber Solder. The surface of the old plate should

be brushed over with it just before packing. The adhesion is so perfect that the plate will break through old or new rubber sooner than separate. Before cutting out the old rubber the part of the plate under the broken teeth should be filled with plaster and then removed, so as to preserve the shape of the ridge; in case the process of repair requires that the plate shall be cut entirely through at this point, it is to be replaced before applying the wax. The second heating darkens the old rubber and makes it more brittle; full cases may admit of one, possibly two, such heatings. Partial cases should be repaired by replacing the entire plate with new rubber, although many repair as in full pieces. We decidedly prefer in both full and partial cases the entire replacement of the rubber. In doing this there are various ways of securing the correct relation of the teeth to the new model. To replace a broken partial or full plate, the teeth being uninjured, attach the broken parts firmly by resinous cement on the lingual surface; soap the rubber, or very slightly oil it, and make a new model; then surround it with a plaster rim, as explained on page 921, coming fully to the edges of the teeth. Remove the resinous cement from the lingual side of the plate and take a plaster copy of this surface and of the inside of the teeth, being careful in partial cases to slope the plaster so that it may be readily drawn. The plaster now enveloping the piece is in three or four parts; remove the plaster from the lingual surface; remove the rim in one or in two pieces; then carefully remove the plate from the model. Soften the rubber plate and remove the teeth; replace the plaster rim around the model and set the teeth or blocks in position, pressing a little wax under each to keep it in place. Now set model, rim, and teeth in the half-flask, first soaking in water to prevent too quick setting of the batter. Soap or cover with foil the plaster surface; then saturate and put in place the remaining lingual piece of plaster; set the other half-flask and pour the remaining half-matrix. Separate flask, pick out the pieces of wax; the case is then ready for packing and vulcanizing. By this process the new plate has the exact shape of the old one, and there is no necessity for molding a new wax plate. If the plate is of such form as to endanger the model in detaching, soften it by cautious use of the blowpipe flame.

If new teeth or block be required, let this be first fitted and wax properly shaped around it; then proceed as above. But if some modification in the shape or thickness of the plate is required, do not fill the lingual surface with plaster; but after making model and rim remove plate, reset teeth, adjust a new wax plate, and then proceed as in a new piece. If the vulcanite rim outside and above the teeth needs modification the plaster rim must be removed and wax placed there also, as in a new piece.

The black deposit which collects on vulcanite plates from long use, or from the smoke of tobacco, can be removed by applying a small quantity of a solution composed of aqua ammonia, alcohol, and chloroform, equal parts, and then adding pulverized pumice stone. After scouring with this mixture, the surface may be polished in the usual manner.

Dr. George B. Snow, in an excellent article on "Repairing Vulcanite Plates," gives the following suggestions:—

"It is not unusual to see vulcanite plates which have been cracked or broken, and repaired by what may be termed the 'hole and plaster' system. Holes are drilled through the plate along the edges of the crack, and a new thickness of rubber superimposed upon a mass which possibly is already too thick for comfort or convenience, the old crack still remaining as a weak point to occasion further breakage. No advantage was taken of any possibility of union between the old and new material, the dentist having been obviously ignorant of the fact that perfect union can be obtained in such cases if the surfaces of contact are freshly cut, absolutely clean, and properly roughened.

"The great point to be remembered in repairing or making any addition to a vulcanite plate is that the new and old material will unite perfectly, and with such firm adhesion that the plate will be practically as good as new if the surfaces of the old plate where union with the new material is desired are freshly filed, *absolutely clean*, properly roughened, and of sufficient area. To insure these results wax should not be melted upon the surfaces of union in waxing up, and removal of the wax from the mold should be accomplished by means of instruments and not by hot water, unless, possibly, for the removal of very small particles which cannot otherwise be got rid of. Any amount of the old material desired may be cut away and its place supplied by new, and thus any change wished may be effected. In case of breakage or cracking the plate should be cut away so that the old defects will be wholly obliterated and new material supplied.

"As a first instance, suppose a partial lower plate supplying the loss of the bicuspids and molars on both sides of the mouth to be broken through the bar which extends from one side of the mouth to the other behind the incisors. The fracture is generally a clean one, resembling that of glass or porcelain, and the two pieces may be brought into apposition with certainty. The dentist holding the parts together in exactly the right position, the assistant covers the lingual side of the plate at the point of fracture with a few drops of hot shellac from a shellac stick. A little cold water follows, and the two parts of the plate are firmly cemented together. A brace is now extended across from the molars on one side to those on the other by laying a burnt

match on the grinding surfaces of the respective teeth and fastening both ends with a few drops of hot wax. By this means sufficient strength is obtained to allow of the plate being safely handled. A piece of paper or sheet-wax is cut to fit and reach across the lingual space at the lower edge of the plate and fastened therein with wax, a coat of shellac varnish is applied to the paper, the surface lathered with soap-suds and rinsed, and a model run in the same manner as in filling an impression.

"After this has hardened the plate is removed from the model, which is then given a coating of liquid silex. This is always preferably done in repairing plates at the time when the plate is first removed from the model. The bar may be now wholly cut away close to the body of the plate on either side by a jeweler's saw, the cut being made diagonally so as to make what is termed a "scarf" joint. The surfaces should be further roughened by making a series of shallow parallel cuts across them with the saw, a thick separating file, or a thin-wheel engine bur. The parts of the plate are placed upon the model, waxed up, and flasked; the model and buccal surfaces of the teeth being covered with plaster, and the parting made so that the plate will be retained upon the model, while the pieces of the bar can be readily removed. After the flask is opened the pieces are removed, the usual gateways cut, and the packing, vulcanizing, and finishing done as usual.

"In the case of an entire lower set broken through the center, it will be seen that the same directions will apply, excepting as to the amount of rubber to be cut away. A free cut should be made on the lingual side, extending through under the teeth, to and including the labial band; so that the broken surfaces will be entirely obliterated and at least one-eighth inch in width of new rubber supplied between the cut surfaces. An engine-bur will do much of this work nicely, and a wheel-bur is very convenient for the purpose of scoring the surface. The making a model, flasking, and packing will be done as before.

"If one of the incisor-blocks be broken and needs replacement, a new one can be fitted after the model is obtained, and the remaining steps of the process followed as has been described.

"Upper plates are sometimes cracked in the center, the crack extending from under and between the incisor teeth backward over the palate. This often happens from the amount of rubber just behind the incisors being insufficient. It is not unusual to see it cut away at this point, so that the pins are almost or quite exposed, the plate having its usual thickness at a very short distance behind the teeth. A much larger amount of material will be tolerated here than is usually employed, and often with benefit, not only to the strength of the plate, but to the articulation of the wearer. The curve of the surface

of the plate should be made to resemble that of the palate before the removal of the teeth, and it will be found that the extra thickness may extend for half an inch behind the teeth without annoyance to the patient.

"A proper curvature to the surface of the plate just behind the incisors will do much to prevent the disagreeable whistling in making the *s* sound, and will assist in giving the correct enunciation to *sh*, *zh*, and other linguals.

"If the cracked plate fits a flat mouth a model can often be drawn from it as it is; but if the arch is high and the gums projecting it is better, after thoroughly cleaning and drying the plate, to finish the cracking by breaking the plate entirely in two. The two halves may now be fastened together by dropping shellac upon the lingual side, and a model secured from which either half of the plate can be easily removed. The whole palatal portion of the plate can then be removed by a saw-cut, leaving only a narrow margin on the lingual surface inside the teeth. The remainder of the surfaces of fracture are cut away as directed in case of the lower plate, the new surfaces roughened, the pieces of the old plate replaced upon the model (which has received its coating of liquid silex), waxed up, flasked, packed, and vulcanized, the teeth being retained upon the model as before described. The plate, when finished, will show the old rim and a margin of the old rubber inside the teeth.

"It is sometimes desirable to change the substance of the plate entirely, as in case of supposed mercurial poisoning by red rubber; or at least to put what red rubber there may be about the plate entirely out of sight and to reduce its quantity to a minimum. If this is to be done to the plate last under consideration, it should be prepared for flasking as described, excepting that the labial band should be cut away, and everything arranged so that the plate can be separated from the model when flasked. The parts cut away should, of course, be replaced by wax. The case is now set in the flask so as to leave the parting at the upper edges of the gums. The plaster is varnished and oiled and more plaster built on against the labial sides of the teeth, extending from their cutting-edges to the edge of the flask, and again varnished and oiled, so that the appearance will now be precisely similar to a plate flasked so as to be retained upon the model. The ring of the flask is now put in place and filled, and the plaster allowed to harden.

"When the flask is separated the teeth will be found in its ring-section. A few blows of the hammer will dislodge them, with the piece of plaster built against their labial surfaces. This is carefully broken away in two pieces if possible, which are preserved, and the teeth and

rubber encasing them is left. The rubber is now filed away as much as is practicable, leaving none of the old rubber in sight and removing enough from the palatal surface to make a new fit to the model. The teeth and plaster are replaced in the flask and the case is ready for packing and vulcanizing, and when finished none of the old rubber will be seen, and the plate will be practically as good as though the teeth had been removed from the old plate and reset.

"It is sometimes difficult to prevent the rubber from showing at the joint between the incisors; great care should be exercised in bringing the sections together properly and in holding them in position while flasking. If there is room a small wisp of loose cotton, not larger than a thread, may be tucked into the joint on its palatal side, the edges of the blocks being beveled to admit of this being done.

"It is evident that the change from red to black rubber just described can be made with a whole plate or a broken one indifferently. If a change of articulation and a new fit to the mouth is also desired on account of shrinkage of the gums, the plate should be prepared so as to draw from the model, and a few small pieces of wax put in the palatal side to bear upon the alveolar ridge, and give the right articulation by trial in the mouth, the center of the plate being cut away to facilitate the fitting of the plate to the model. A fresh model of the mouth being secured from an impression, the plate is waxed on to it, the case is flasked with a false piece of plaster built against the labial sides of the teeth as has been before described, and the plate afterward removed and cut away as much as desired, a considerable amount always being taken from its palatal surface.

"This process not only gives a new fit, but allows the material of the plate to be substantially changed. Holes and dovetails, it will be seen, are wholly unnecessary, and the fine serrated edge left by cross-cutting the surfaces of union will be found an excellent guide in scraping the plate to avoid overlaps. The use of shellac as a cement is strongly advised in repairing, as it is rigid and brittle when cold, and the broken parts, if once properly brought together, cannot get out of adjustment without at once attracting attention by the breakage of the cement. Wax does not answer the purpose nearly so well.

"The amount of shrinkage in vulcanite from cooling after vulcanization is not so generally noticed and provided for as it should be. Plates composed of single teeth do not give trouble from this cause, but full plates on which sections are mounted are often very vexatious to the dentist from the change of shape they undergo from shrinkage.

The reason of this is that the ends of the sections abutting form an

arch of porcelain, which expands or contracts but slightly from changes of temperature. The rib of vulcanite immediately inside this arch, and in which the pins are imbedded, forms a second arch closely attached by the pins to the first one. The plate is molded to the model and hardened at a temperature of about 320°, and is afterward placed in the mouth, where the temperature is in the neighborhood of 90°. Under these circumstances the contraction of the rubber which ensues has the effect of lessening the radius of the arch, drawing the heels of the plate together, thus rendering it a little too narrow to fit the mouth accurately. This has the further effect of elevating the palatal portion of the plate, which, when tried in the mouth, will usually be found to rock slightly, often so much as to interfere with its fitting.

"If the plate has been made upon a model taken from the mouth the difficulty is overcome by warming the back part of its palatal portion, pressing it down slightly, and cooling it while the pressure is continued, the narrowing of the plate being too small in amount to be itself objectionable.

"This change can be accomplished with more certainty by making a small plaster cast of the palatal portion of the plate, placing upon the part where the change is desired a small piece of folded paper, folded so as to present a thick center, and forcing the plate down upon it after its palatal portion has been warmed.

"The shrinkage here alluded to becomes a more serious matter when the plate is re-vulcanized in the course of repairing it. It is flasked when the change in form by its shrinkage has already once manifested itself, and again heated to 320°; and in cooling a second shrinkage takes place, it becomes still narrower, and its fit, already defective, is made perceptibly worse. It now often becomes a matter of necessity to bring it back to its proper shape before it can be worn with comfort. To provide for this a small dot should be made with a pointed instrument on each side of the plate immediately behind the molars, and a pair of dividers set to the distance between these points. After vulcanization the dividers can be applied to the marks, and they will indicate the amount of shrinkage the plate has experienced. Let the plate now be warmed just behind the incisors and in the mesial line by repeated short puffs of a blowpipe flame. This must be done carefully and the heat not allowed to extend over an area much exceeding half an inch in diameter. When the rubber is sufficiently softened the plate should be taken by the heels, a pull made upon it sufficiently forcible to expand the arch, and a stream of cold water applied. The dividers will at once show if the change made is sufficient.

"When the plate is now tried in the mouth it may be that the back edge will not touch the roof, and air will be admitted under the plate, in which case the back edge should be warmed and forced up to its proper position.

"The same remarks apply to full lower plates as well, which often are found to have lost their fit in a measure, after having been re-vulcanized. The process above detailed will suffice to restore them to their former fit and render them again comfortable to the wearer."

If the teeth are to be reset because of change from absorption, or because of some inaccuracy in the fit of the plate, it will perhaps be best, in most cases, to proceed just as for a new piece, grinding the joints again for any change of arrangement. Sometimes rejointing the blocks may be saved by bedding their cutting edges and cusps in a gutta-percha rim before detaching from the plate; this will permit their adjustment to the new wax plate in a continuous arch. Sometimes the old plate may with advantage be used as an impression cup by roughening the rubber and using a very thin layer of wax or plaster, whichever best suits the case. In making the model extend it backward, as before described under Articulation of Plastic Work. Before removing the piece complete the articulator, making the plaster cover the edges and crowns of the teeth one-eighth of an inch. By setting the blocks, when removed from the old plate, into their depressions on the articulator the exact relations of blocks to the model is preserved; also, if the plaster of the impression is made accidentally too thick the articulator may be slightly closed. The wax plate is arranged first on the outside; the half-articulator is then removed and the inner part of the plate shaped. The articulating portion is then cut off, the model set in the flask, and the process completed in the usual manner.

Gold, platina, or aluminium plates may also be re-fitted to suit a mouth changed by absorption. Perforate the plate with holes about size No. 22 (Fig. 921), countersunk on lingual side, regularly arranged and about half an inch apart. Fill the lingual surface between teeth with plaster; remove this when hard and make countersinks in it opposite each hole in the plate. Set the plate on model and fasten it with wax around the entire edge; then place in half flask as usual. Replace the countersunk pieces of plaster and pour second half matrix; this piece of plaster and the wax around the edge prevent the batter of the matrix from getting between plate and model. Separate flask, cut vents, put in a sheet of prepared rubber of proper size, press matrix together, and vulcanize. The impression may be taken in the usual cups or in the plate itself, and with either plaster or wax, as the case may require; if taken in the plate, cleanse this carefully after making the model. The adhesion of the rubber may be increased by cutting

the palatine surface of the metallic plate with a sharp graver; it should be carefully cleansed just before packing the rubber.

Dr. Richardson gives the following method of refitting gold or vulcanite plates with a new vulcanite lining: "Perforate the palatal portions of the plate with from eight to twelve holes at different points, and also the extreme borders, from heel to heel of the plate, at intervals of one-eighth to half an inch apart and near the edges. These holes may be enlarged to the dimensions of a medium-sized knitting-needle; or, if the piece is of vulcanite, to twice or three times that size. On the lingual and buccal surfaces the holes are well countersunk with a bur drill. The plate is employed as a cup or holder to take an impression of the mouth in plaster, being pressed up closely to the parts. The plaster forced through the holes, and filling the countersinks on the opposite side of the plate, will serve to bind the plaster to the plate and prevent the two from separating as they are detached from the mouth. When removed the plaster impression lining the plate is trimmed even with the borders of the latter and varnished and oiled. The lower section of the vulcanizing flask is now filled with a batter of plaster on a level with its upper surface, and the impression filled with the same is turned over and placed in the center of the flask, with the edges of the plate touching the surface of the plaster. The plate and adhering plaster are now carefully separated from the model. After cutting out the plaster from the holes and countersinks in the plate the plaster forming the impression is detached from the plate and the holes and countersinks filled with wax. The plate is then re-adjusted over the model and (the surrounding surface of the plaster in the flask having been varnished and oiled) plaster is poured in upon the upper surface of the plate and teeth, filling the upper ring. When the plaster is sufficiently hard the two sections of the flask are separated and grooves formed, running out from the matrix to the margins of the flask. A sufficient quantity of vulcanizable rubber is now either placed upon the model or packed in upon the palatal surface of the plate; before doing which, however, the wax filling the holes and countersinks in the plate (and which was placed there to prevent portions of plaster last poured, in forming the matrix, from filling them up) should be worked out with a small instrument. The whole being sufficiently heated, the two sections of the flask are forced together, expelling redundant material. The piece is then vulcanized."

The late Dr. Wildman suggested the following method of forming a new plate without changing the articulation of the teeth: "Roughen the palatal surface of the rubber plate to cause the plaster to adhere to it; then use it as an impression cup to take a plaster impression, being careful, when it is in the mouth, to preserve the articulation.

In this impression cast the model; trim and cut conical holes at several points in its outer face. Now, before separating the impression from the model, make a cast of the face of the teeth in two or three perpendicular sections, extending to the base of the model, using a solution of soap or other parting substance on the plaster model. Remove this mold of the face of the teeth, which indicates their true position relative to the model. Then take the impression from the model. By the aid of heat sufficient to soften the rubber remove the teeth from it. Next make a model plate with prepared gutta-percha, 'wax and paraffin (or modeling composition).' Now secure the sections of the mold of the face of the teeth to the model (their place will be indicated by the conical holes or keys); adjust the teeth in their proper positions in the plaster mold of them, and build up with wax to the proper form of the model set. This being done, test its accuracy of contour and articulation by placing it in the mouth. Then, using the model, proceed as for making a new set."

The method just described requires the presence of the patient; but cases occur where this is not possible, and owing to accident a new plate is necessary and the articulation must be preserved. Take a case, for an example, where the plate is so fractured that it cannot be repaired, and yet is capable of being temporarily adjusted by means of hot wax dropped from a spatula. When this is done the palatal surface of the plate is coated lightly with oil and plaster batter poured into it to form a model. Then trim the edges of the plate and sides of the model, and form holes of a conical shape to act as keys for the mold, which is made in sections of the outer face of the teeth. When this mold has become hard the sections of it are removed, as well as the plate from the plaster model. Undercuts may prevent the ready removal of the old vulcanite plate, and in such a case, to prevent injury to the model, the old plate should be softened by heat. The subsequent manipulation is the same as in the previous method.

When the plate is broken in half a rubber plate may be repaired by a method suggested by Dr. Gilbert: "Remove the denture, and with a fine Swiss saw cut away the palatal portion of the plate to within about an eighth of an inch of the inner surface of the teeth. In this remaining portion cut dovetails to retain the new rubber, and also form an undercut channel in the portion which fits over the alveolar ridge in the line of the break, as far as the edge of the rim; secure the parts to the model with wax. The cut-out palatal portion may then be laid back in place to aid in waxing up that part. Invest in the flask, covering the labial and grinding portions of the teeth, as in other repair work. After separating remove the part desired to be replaced with new material; pack and vulcanize as usual."

Partial pieces can usually be retained by stays and the fit of the plate. If clasps are called for these may be made of rubber alone if the clasps are short and the rubber elastic; or of rubber strengthened by a gold wire, which is to be curved around the clasp tooth just before packing. A gold clasp may also be fitted and retained in the rubber either by a projecting slip of the same metal or by soldering into it one or two platinum pins.

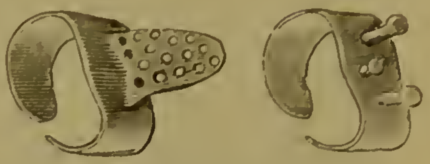


FIG. 1151.

Fig. 1151, taken from Prof. Wildman's monograph, represents these two forms of clasp; but in cases requiring clasps we very decidedly prefer a gold plate. The larger size of vulcanite plates necessary for strength will usually secure adhesion with the help of stays or half clasps; in none of these cases do we consider the vacuum cavity of any service.

Combination of Vulcanite and Metallic Plates.—Section or single plain and gum teeth may be secured to gold or aluminium plates by vulcanite instead of by soldering. Blocks having a porcelain gum on the inside, finished to the plate and having a countersunk base in which are platinum pins, present a very handsome appearance when attached to gold plate by vulcanite, and may be made very secure. The hole should be of good size, but must not come so near the translucent front of the tooth as to permit the color of the rubber to darken it. In this and the subsequent modes of attachment the swaging, articulation, and grinding of blocks is done as usual, except that there is less necessity for close fitting to the plate than in case of soldered work. The temporary plaster rim, elsewhere described, must in all cases be used, so as to permit removal and correct replacement of teeth. Where blocks or single teeth with holes in the base are to be supported by pins soldered to the plate, which is another mode of attachment, press each block into place over a thin layer of wax on the gold plate. The wax projection made by each hole shows where to drill the plate for the pins; then remove plate, drill holes, and solder roughened or headed pins into the plate opposite each hole; fasten the blocks temporarily with wax, then invest in the vulcanizing flask, so that on separating the matrix the plate shall come away in one half, the teeth in the other. Fill the holes with rubber and place a strip over the base of the blocks; warm and replace the two halves of the matrix, and vulcanize. Vulcanite blocks, such as those in Figs. 1152 and 1153, may be very firmly attached to metal plates by some one of the methods represented in Fig. 1154. Set the teeth or blocks in the temporary plaster rim and distinctly mark a line around the ridge, just under the head of the pins (C); mark across this line the position

of each pin (*a*, *b*, *c*, *d*); then remove blocks and prepare the plate for the different plans of retaining the vulcanite. 1st. For an aluminium plate which can have no soldered pins drill a row of small holes on the line between the pins; set it in the counter-die, and with a tapering punch enlarge each hole, with the projecting bur next

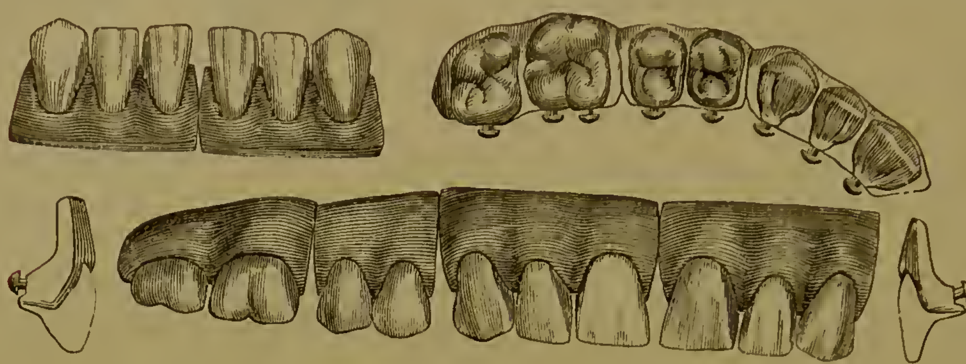


FIG. 1152. FIG. 1153.

the tooth (C, *c*). Let each hole be not smaller than No. 20 (Fig. 921). In some cases a smaller set of holes may be punched or drilled in the outer edge above the gum (C). Swage the plate again to correct the effect of this punching; then place it on model, replace blocks, arrange wax, and prepare for vulcanizing. 2d. Arrange the plate firmly on a piece of charcoal, set small cups of gold or platina on the line, between the pins (A, *a*), with a small piece of solder at each, and solder them all at one heating. 3d. Or drill small holes on the line, between the pins of the teeth (B, *b*), and insert headed platina or gold pins and solder them. 4th. Or drill two holes between the tooth-pins (E, *e*) and insert a loop; only one hole is really necessary, as the other end of the loop may be shortened so as just to touch the plate, to which the solder will attach it. 5th. Lastly, a wire may be bent in a series of waves (*d*), so as to pass under each tooth-pin (or just behind it if the pin is too close to the plate, but never over it) and rise from the plate between the pins. Adjust this wire accurately, with the blocks in place; mark the points of contact; then remove plate and solder the wire. The last four methods are applicable to gold and platinum, which admit of soldering. In soldering no plaster investment must be used, and the plate must have a good support on the charcoal; with these precautions careful soldering will not warp or spring the plate. If sprung

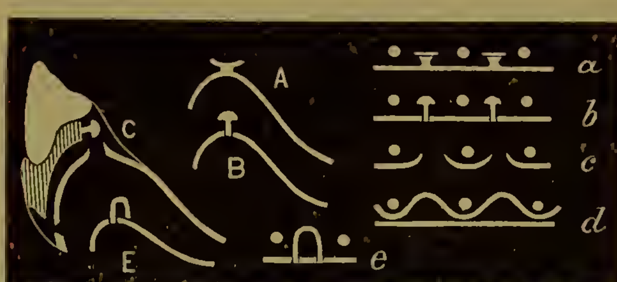


FIG. 1154.

the pins and loops make it necessary to cut a deep groove in the lead counter-die before attempting to swage.

After completing either of the five plans here described re-adjust the teeth in the plaster rim and fasten them in place with wax, trimmed to the shape required for the vulcanite; then invest in the flask and vulcanize as before described. By avoiding excess of rubber, using only so much as is necessary to conceal the pins or loops, the vulcanite band may have a very neat appearance. Some dentists partly conceal the rubber by an inside and outside band; but if concealment is necessary, we should prefer to do it by the form of blocks above given. If the inside band is used the simplest method is to mark the line of its position; then, by skillful use of the hammer, a strip of gold can be *paned* and with the pliers *bent* so as to have a uniform slope and a close fit; a file will be necessary over small prominences.; this method of paning is simpler than either swaging a band or first making a lead or tin pattern. If cast plates of aluminium or other metal alloys are used it is only necessary to drill holes, as many, and of such size, as may be thought necessary, in that part of the plate next the blocks; they may pass through to the palatine surface if necessary and be countersunk. It is very important to ascertain, by trial, that the closely fitting edge of aluminium does not interfere with the teeth in separating and replacing the flask.

A method of attaching porcelain teeth to a metal base with vulcanite was devised by Dr. P. G. C. Hunt, and a process very similar was afterward introduced by Dr. Engle. It is described by Dr. Hunt as follows: "Thus far we proceed as we do for ordinary gold plate work. We will now suppose the teeth ground and jointed, leaving as much space between the teeth and plate as the plate will admit of. We next mark with a sharp-pointed instrument on the labial surface of the plate each point where it is necessary to place a loop for purposes hereinafter described; then apply wax to the external or labial parts of the teeth and plate, in any manner sufficient to retain the teeth in position; remove the wax from the lingual parts of the teeth and plate, and mark the position on the metal where it is desirable to insert the loops; remove the teeth and wax, and with a small bow-drill make holes through the plate at the several points previously determined on for the attachments about the size of an ordinary plate-punch hole; take a wire or ordinary gold plate cut in strips, say from a half to one line in width, being governed by the amount of room there is under the base of the teeth, and with small round-nosed pliers bend the strip around; grasp both ends with square-nosed pliers; draw the round-nosed pliers from the loop, still grasping the square-nosed pliers with the left hand, and with a hammer strike the top of the loop a sufficient

blow to keep the ends from springing apart; cut off the ends and dress down to fit the holes in the plate; after which solder on charcoal or other suitable substance without investment. Fig. 1155 illustrates the bent or hooked wire soldered to the base. Pickle, dress, and polish that portion of the plate to be exposed to view. Bend and flatten the pins; arrange the teeth, waxing so as to cover up the loops if practicable. The loops should be placed as near the base of the teeth as possible, the rubber forming, when finished, a part of the general concave shape which is desirable in upper dentures and which it is

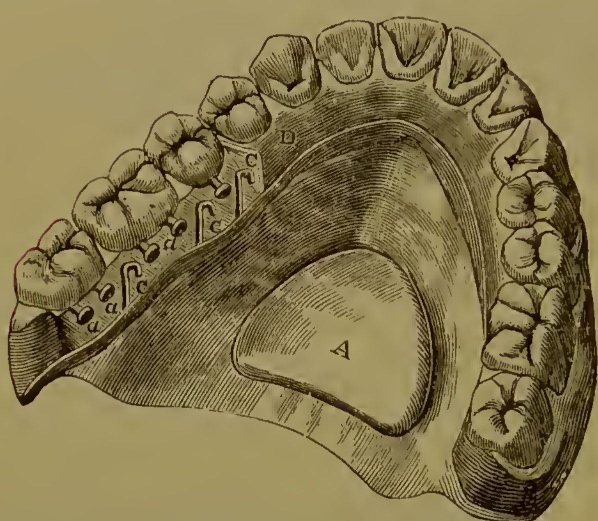


FIG. 1155.

FIG. 1156.

not possible to obtain with ordinary soldered work. Then with silicate of soda paint the joints, to keep the rubber from forcing in where it would show after vulcanizing. Flask, vulcanize, and finish as usual.

A punch for forming loops in metal plates, and especially for aluminium plates, is represented by Fig. 1156. The size of the loop may be regulated by a thumbscrew.

Celluloid can be attached to a metal plate with the same loops and hooks by sawing out the palatal portion of the celluloid blank, and

trimming away as much of the remaining portion which covers the alveolar ridge as is necessary to avoid having an excess of material. When investing the piece the line of separation is made at the edge of the wax rim, thus permitting the plaster to cover the palatal portion of the metal. When the sections of the flask are separated the metal plate will occupy the lower and the teeth the upper portions.

The attachment of vulcanite to metal plates is an extremely useful and important application. It loses one of the peculiar advantages claimed for vulcanite, the accurate fit of the plate; but it makes very strong work, and is more cleanly than ordinary swaged work, because all interstices are completely closed. It also gives a shape behind the teeth more conformable to the natural shape of the teeth and gum. It obviates two of the principal objections urged against vulcanite—thickness of the plate and contact of the rubber against the gum and tongue. It dispenses with that accurate grinding of the base of blocks required in ordinary gold work, and obviates the risks of the soldering process. It is applicable to full sets, or to partial sets where the teeth are in groups of three or more. It is best repaired by removing the entire vulcanite attachment; but those who patch up old rubber plates can, with greater impunity, patch the "combination work;" since the strength of the piece depends mainly on the plate, the brittleness of second heating is of less moment. Another argument in its favor is that it makes available to gold-dentists the beautiful forms of rubber blocks, without identifying them with that class of rubber-dentists who, by accommodating the style of their work to the cheapness of the material, have brought much discredit upon dental mechanism. Dr. R. M. Chase has invented what he styles "a metallic-roof plate," which comprises a plate of gold or other metal to cover the roof of the mouth and a vulcanized extension attached to the edges of such a plate and extending over the alveolar ridge. The edge of the metallic plate is serrated or notched, and bent upward at an angle so that the vulcanite portion can be attached. In such a denture the metal portion only comes in contact with the roof of the mouth, while the vulcanite is restricted to the under and outer surfaces of the alveolar ridge. The method of constructing such a denture is described by Dr. Chase as follows: "Shape the plaster model so that it will easily drop from the sand by its own shape and weight by simply raising the flask at a right angle from the table. After shaping the model as described, mold wax and paraffin base-plate to the labial and buccal portion of the alveolar ridge of the model, filling all undercuts and irregularities, letting it extend over on to the alveolar ridge to the depth of from one-eighth to one-quarter of an inch. This should be beveled toward the palatine aspect, this being done with a view to

where the turned-up edge of the plate will not interfere with the pins of the teeth. The whole model, including the wax, should be shaped on a true bevel from the base to the beveled edge. Varnish the model, including the paraffin wax, with two or three coats of white shellac dissolved in alcohol. A model when prepared in this manner presents a beveled surface at all points, which makes sand-molding simplicity itself. When the shellac varnish is dry mold in fine sand. Do not pack the sand over the face of the model but a trifle, rather depend upon the weight of the sand to do this. Pack thoroughly around the side and top of the flask, so that when it is leveled off and reversed none will drop out.

"Having secured the impression of the model, melt zinc and make a die. When the die is cool reverse it and pack sand around it nearly as high as the top of the ridge, so that only the palatine surface and the beveled edge is exposed. Place over this a rim of iron about one inch larger in diameter than the die, and pour melted lead into the rim to the depth of one inch. Remove this counter-die and make another, but do not let the sand extend up higher than half an inch from the top of the ridge. The first counter serves to shape and partially swage upon. When this is done trim the edge of the plate where it bends over the edge of the die to the proper shape, not letting it extend beyond the top of the beveled edge. The second counter serves for the final swaging. It is seldom necessary to make more than one die and two counter-dies as described. When the plate is shaped upon the first counter, notch the turned-up edge about one-eighth of an inch apart, cutting into the metal to about one-thirty-second of an inch—where the turned-up edge commences or where it is to leave the cast, place back upon the die and smooth down the notched points, which will curl up in cutting. Anneal and place upon counter No. 2 and strike the die with two or three dead, pushing blows; this will finish the swaging process. Now saw or trim off the base of the model, remove the wax and paraffin, and adjust the trial-plate. Secure the bite or articulation; after this is done remove the trial-plate and fasten the metallic plate to the cast in position by a few drops of wax. Soften base plate, place this upon the labial and buccal surface of the cast, connecting it with the edge of the plate. Proceed to wax up the teeth in usual manner, letting the wax-backing extend on to the plate as far as desired when finished. When adjustment of the teeth and waxing process are completed, flask the same as for rubber, except the plaster should cover the metallic plate, extending a little above the edge or border of the wax. Soap the plaster, adjust the upper half of the flask, and fill with plaster. When hard, warm the flask and open. Remove all wax by pouring boiling hot water upon

it. Now, with a pair of narrow beak forceps, bend the notched parts every other one in opposite directions. This gives additional security against becoming detached when the extension is molded to it; vulcanize and finish.'' A vulcanized plate may be bleached by placing it in a glass vessel containing alcohol, and exposing to the sun's rays for from four to six hours; covering the top of the vessel with a plate of glass will prevent rapid evaporation. The pink rubber employed to give a more natural color to the gum requires to be bleached in order to render it sightly. To remove teeth from a vulcanite plate the piece may either be passed through an alcohol flame until the teeth become hot, or the set may be boiled in oil or imbedded in hot sand of such a temperature as will not char the plate. The latter method is preferable when care is taken to have the sand at a proper temperature, as the teeth or sectional blocks can be readily detached and all rubber adhering to the pins be removed by means of a pointed excavator. Any slight imperfections in a vulcanite plate in the form of a small hole left by plaster particles can be repaired by melting gum shellac and incorporating it with vulcanite filings. A cement thus formed can be introduced in a plastic state and made smooth with a heated spatula or burnisher.

Rubber can be made liquid for use as a rubber solder by cutting it into small pieces and dissolving by either benzine, turpentine, chloroform, ether, or bisulphid of carbon, all of these agents being solvents of rubber. The shape of a vulcanite plate can be changed by obtaining a correct impression and model of the mouth, upon which the plate, having been previously heated, is pressed by means of a napkin or piece of chamois skin, and held in position until it is cold. To soften the rubber plate the set may be immersed in boiling water, or placed in an oven with the teeth downward until the rubber becomes pliable; in the latter method care should be taken that the rubber is not blistered or charred. A more certain method, however, is to reconstruct the set.

For quick repair in the case of a broken tooth or sectional block a hard, quick-setting amalgam is sometimes employed, first cutting out a suitable cavity about the space to be filled, and after the tooth is properly adjusted packing the amalgam under it and about the pins, the tooth being firmly held in place during the operation. Wood's fusible metal has also been used for the same purpose and to close holes, the latter being countersunk on both surfaces and made oblong.

Springplates consist of elastic partial pieces which are so constructed and vulcanized as to press against certain natural teeth, and thus be retained in position. After securing the model a little of the palatal surfaces of the plaster bicuspids and molars is scraped away, and in

forming the trial plate the wax is allowed to extend some distance from the necks of the retaining teeth upon the model, toward the grinding surfaces, in the form of partial stays. These plates are so shaped as to leave the central portion of the mouth free, no air-chambers or clasps being necessary. As the tendency of spring plates is to press the retaining teeth outward, they are not generally used. For mouths having soft places Dr. Land recommends an air-chamber covering four-fifths of the palatine arch and including certain parts of the alveolar walls (pages 973 and 974) ; and the same writer remarks : "To insure a comfortable adaptation the pressure must be so equalized that, as the alveolar ridge recedes, undue stress will not be brought on the palate. For this reason an air space, covering almost the entire surface of the palatine arch, is desirable, as thus the pressure is better distributed and brought to bear directly on the alveolar ridge, where there will be the least danger of injuring the mouth, thus avoiding the riding or rocking of the plate on the hard palate. The conventional air chamber, with its acute angles invariably placed on the most rigid portion of the hard palate, soon outlines itself in the tissues, demonstrating a failure to properly utilize atmospheric pressure and injuring the mouth by inducing absorption unnecessarily."

Dr. Hurd has suggested what he terms a "flange section" for lower plates, which is described as follows: An impression is first taken in wax, and this is used to obtain a plaster impression. The extreme projecting plaster at the sides of the tongue is cut off, and the surface varnished and filled up, so as to make a full model across from heel to heel, running far back upon the process, to keep the lip from pressing the plate back when the force of the muscles and lip is brought to bear upon it. After obtaining a correct articulation, a gutta-percha plate being used for the purpose, the teeth are set directly upon the center of the margin, perpendicular in front, but inclined at the sides, so as to allow for a sufficient space to form an outer flange for the lip to press down upon. This flange is then made by means of wax about one-third of an inch thick, with the inner surface rounded up in the same manner as the outside, but not made so thick and high, for the tongue to rest upon and keep down, thus excluding the air, the saliva which collects under the tongue also aiding in making the vacuum. It is necessary that the flange should rest gently against the cheek to give steadiness to the plate, and the teeth must be so arranged that they are level on the face. After vulcanizing, the piece is first cut away by filing at the hard margin on the under side of the outside flange, and increasing it near the edge of the plate at the cheek, and making a chamber. The inside of the plate is also cut away to free it from the sublingual muscles and glands, which tend to elevate the plate

when the tongue moves upward. In cases of malformation a thin, flexible rubber flange may be attached to the plate instead of the hard flange, so as to hold securely and conform to the movements of the muscles.

Lining Vulcanite Plates with Gold.—Vulcanite plates are sometimes covered with a gold lining on the palatine surface to prevent the contact of the rubber with the mucous membrane. What is known as the "vulcan gold lining" is composed of chemically pure gold, with a thin covering of pure silver. The flask is packed as usual and the gold is applied in one piece to the surface to be covered. The union between the rubber plate and the gold covering is mechanical; and the sulphur in the rubber when set free by the action of vulcanizing attacks the silver, sulphurizing the surface, and to this the rubber tightly adheres.

If the rubber plate is covered by the gold on both sides it is claimed that the vulcanite becomes tougher when vulcanized, for the reason that during this process the pressure against the metal gives the plate a surface more dense than it will have if vulcanized in contact with plaster. The sheets of this form of gold are of the thickness of No. 20 foil.

Vulcanite for Irregularity Appliances.—Of the peculiar adaptation of the vulcanite material to the correction of irregularity mention has been made in the chapter on that subject. No further special directions are required except on two points: first, to have the plaster which makes the model perfectly smooth and free from air bubbles; secondly, to coat the teeth before vulcanizing with soluble glass or collodion solution. Attention to these two points will give a plate which, if the impression is correct, will fit the teeth with most perfect accuracy.

Directions to Patient.—Upon the completion and insertion of a vulcanite piece the patient should be cautioned to cleanse it thoroughly at least once a day; also to keep it in water when not worn in the mouth. Extreme cleanliness is advisable in all kinds of artificial work, and many patients need no such direction; the special necessity for care in the case of vulcanite arises from the tenacity with which the mucous secretions adhere to the surface if from neglect they are allowed to collect upon it. This coating is most apt to collect at those points where the friction of the tongue and of the food does not remove it; the same care is necessary for its daily removal as is required to keep the natural teeth in good order. There is, however, this difference between cleanliness of the teeth and of the plate, that while both are essential to purity of the mouth, the secretions have no chemical action upon the plate, as they have upon the teeth.

One point affecting the durability of vulcanite plates has, perhaps, not been determined by a sufficient experience. It is well known that

silver and eighteen-carat gold undergo a change in the mouth which causes them to become more or less brittle; such is not the case with twenty-carat gold and with platinum. The change in these cases is partly the effect of mastication, acting as do the repeated blows of swaging; partly a galvanic action between the molecules of the alloyed metal. A similar but much more rapid change takes place in the gutta-percha which is used for impressions; also in the vulcanized gutta-percha and in all those preparations of vulcanized rubber with which foreign substances are largely mixed for the purpose of modifying the brown or red color. The brown rubber, being purer, will probably retain its toughness and elasticity longer than the red rubber. We have some specimen pieces of red rubber which seem, at the end of twelve years, to possess their original strength; and we know of one partial piece that has been worn constantly for ten years, which has never been repaired, and seems as strong as when first made. This point, however, requires the collected experience of many observers during a period of many years, carefully distinguishing between the brittleness of over-baking or twice vulcanizing, and that which may supervene as the result of certain molecular changes in the substance of the material. It is a change which, unlike the galvanic action in gold and silver plate, may not require the presence of the buccal fluids, but which will probably take place alike out of the mouth as in; for such is shown to be the case with gutta-percha.

CELLULOID.

Celluloid, like vulcanized rubber, a cheap base for artificial dentures, was first introduced in 1869, and during the existence of the "rubber patents" was much used by those who objected to become licensees of the Goodyear Rubber Company. The comparatively recent improvements made in the material, and methods of manipulating it, have commended celluloid to professional favor as a plastic substance more in harmony with the soft tissues of the mouth, as regards natural gum color, than rubber, although it is more liable than the latter substance to change form after molding and to absorb the oral secretions if not properly manipulated. Celluloid is obtained from cellulose, the woody fibre which constitutes the framework of plants, examples of which are furnished by hemp, linen, cotton-wool, etc. In the manufacture of celluloid the cellulose of hemp, which is the strongest, is first converted into paper by the usual method, its chemical properties during this process remaining unchanged. The hemp paper is then converted into pyroxylin (gun cotton), by immersing the paper in a strong mixture of nitric and sulphuric acids, afterward being thoroughly washed.

This process increases its weight about seventy per cent. and renders it highly explosive, taking fire at 300° Fahrenheit.

The pyroxylin is then reduced to a pulp, and a mixture made of the following ingredients: Pyroxylin, 100 parts; camphor, 40 parts; oxid of zinc, 2 parts; vermilion, 0.6 part. It will be seen, therefore, that celluloid is composed principally of pyroxylin, with camphor (dissolved in alcohol) as a solvent, and that it contains less vermilion than the red vulcanizable rubbers. After the ingredients are thoroughly mixed immense pressure is brought to bear upon the mass by means of a hydraulic press of two thousand pounds to the square inch, which squeezes the celluloid through a small orifice in the side, near the bottom of a strong cylinder. This pressure is necessary to condense and solidify the celluloid, which, as it presses out of the orifice in the cylinder, is cut into pieces and molded by heat and pressure into forms suitable for dental use, called "blanks," and which in size and shape approximate to the bases of upper and lower dentures. These "blanks" are then seasoned for some two months in a room kept at a temperature of 160° Fahrenheit, when they are ready for use. To manipulate a celluloid blank into a proper denture is by no means as easy an operation as the working of vulcanizable rubber, celluloid being a material that is liable to alteration in shape and character under different circumstances. Repeated failures are the result of manipulating celluloid like vulcanizable rubber; hence perfect molds, equal pressure, and metal dies are absolutely necessary for the usefulness and durability of such a denture. Experience proves that metal dies, which produce a surface proof against disintegration, are alone reliable. The coating of the surface of a wax and paraffin plate, and also of the plaster model, with tin foil, overcomes somewhat the difficulty of preventing the loss of too much of the camphor solvent by absorption, and obviates the necessity of removing the original surface possessed by a celluloid plate when it is taken from the heater.

In the preparation of a celluloid denture the manipulations are the same as for vulcanized rubber until the case is ready to invest in the flask. The plaster used for working celluloid should be of the best quality, and not mixed too thin. The pink paraffin and wax answers better than any other material for a base plate, a thin paraffin-and-wax sheet being used for the plate, which is strengthened by adding to its surface either warmed paraffin or modeling composition, first covering the paraffin plate with No. 60 tin foil in order that the modeling composition may be removed without injuring the smooth surface of the thin paraffin base plate. The teeth are arranged upon the base plate and secured by dropping melted paraffin and wax around their roots A stick-form of paraffin and wax can be obtained, which

is very convenient, the method of using it being represented in Fig. 1157.

FIG. 1157.

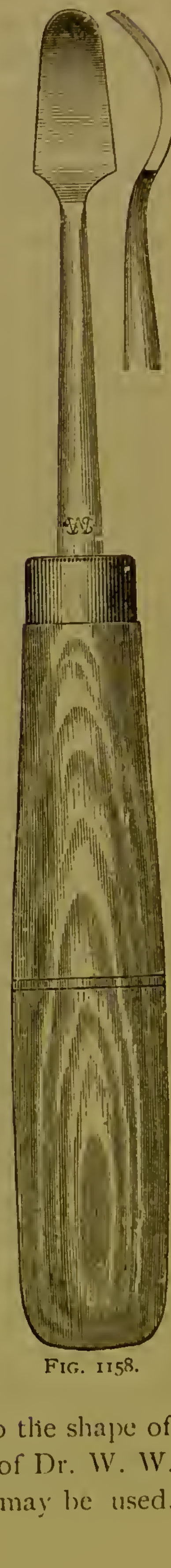


FIG. 1158.

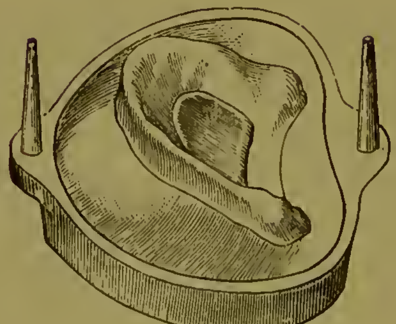


FIG. 1159.

The paraffin and wax compound is then carved into the shape of the gum desired by carving instruments, such as the set of Dr. W. W. Evans, represented in Fig. 1127; or a simple scraper may be used,

such as is represented in Fig. 1158. The surface of the paraffin and wax may be made very smooth by directing upon it the flame of an alcohol lamp with a blowpipe, care being taken to preserve the outlines of the carved gum. The more perfectly the wax is carved and smoothed, the less finishing of the surface of the celluloid will be necessary. The surface of the wax is then covered with heavy tin foil, which is burnished down lightly and smoothly.

The case is now ready for investing or flasking, after which the grooves are cut for excess of material; and in every case the parting of the flask should be at the edge of the wax, and the wax, teeth, and foil removed with the upper half of the flask, so that the surface of the model or cast is left clean and entirely exposed.

To prevent breaking a plaster cast, in cases of deep undercut, the method of investment suggested by the late Dr. Wildman should be followed. "It consists simply in so investing the cast that it shall occupy the position shown in Fig. 1159. If so placed, the pressure applied in molding is brought to bear upon the mass of plaster supporting the projection, instead of upon a thin section." Cutting away the base of the cast at the heel before investing it will elevate the anterior part in the manner referred to. After the sections of the flask are separated, the wax is removed by pouring boiling water upon it from the spout of a kettle, when the tin foil will remain upon the plaster surface. In some cases it may be necessary to cut away the thin edge of plaster which projects over the mold in the section of the flask containing the teeth. It is recommended to cut a groove for excess of material around the inside of the flask, about one-eighth of an inch from the model, and in this section of the flask, with no cross grooves connecting the main groove with the model, as is done in the case of vulcanite. All sharp edges of plaster liable to break off should be removed or rounded, and many prefer, especially when gum teeth are used, to cut away the plaster between the model and the edge of the flask all around, about the thirty-second of an inch, to allow the surplus celluloid to escape without pressing too much upon the gums of the teeth. In using a celluloid blank care should be taken to select one as near the size of the surface of the model as possible, for all folding, owing to too great width at the sides, will form creases in the plate; the blank may be reduced to a proper size by cutting down. Celluloid may be molded with steam, glycerin, or oil, and by dry heat, the latter giving the most perfect results. Fig. 1160 represents a sectional diagram of the steam molding apparatus of the Celluloid Manufacturing Company.

In using this steam apparatus the boiler is partly filled with water, the quantity being sufficient to cover the ribs at the bottom. The

screw is turned back so far that the plunger when in position is resting against the top of the boiler, so that the model may not be injured by pressure upon the flask while the cover is being screwed down. It is very necessary that the cover should be well turned down, the gland turned back, and the screw working easily, otherwise it is impossible to determine how much pressure is exerted; for if too much, the teeth or model may be broken, and if too little, the result is a porous plate. After the flask is placed in the appa-

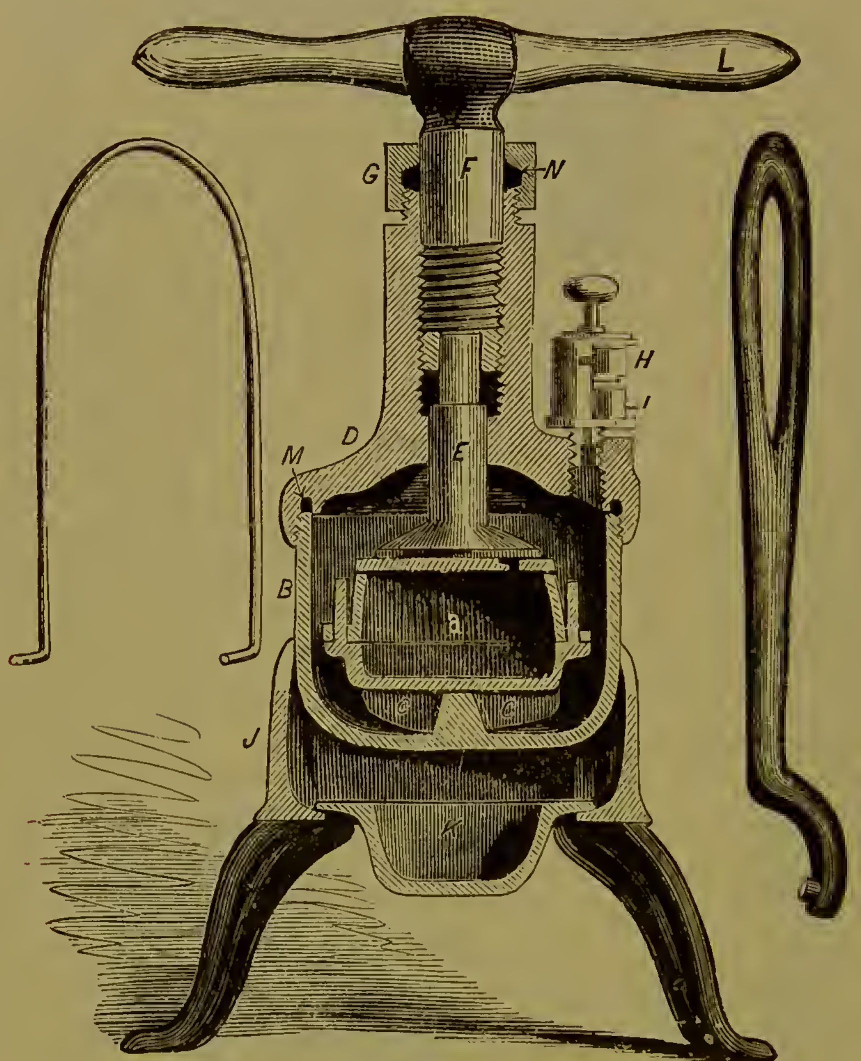


FIG. 1160.

ratus the screw is turned down very gently with the thumb and finger, until it is felt to touch the flask. The heat, which may be generated with alcohol, kerosene, or gas, is then applied. The upper portion of the safety valve, which consists of two parts, may be suspended by the pins in the lead weight, and this valve should not allow the steam to escape at a temperature of 225° F. When the steam begins to blow off, strict attention is necessary, as the plate is readily

injured by too much heat without the required pressure. The time necessary from this point, with the properly regulated heat, is from fifteen to twenty minutes. When the steam escapes from the valve, its upper portion being suspended, the plate begins to soften, and the screw is easily turned with the thumb and finger, when the upper weight should be dropped down. The screw is again turned very carefully, the pressure ceasing as soon as resistance is felt, and continued when it again yields. This careful screwing down is kept up, and the pressure somewhat increased as the steam rises, which can be determined by raising the valve, the object being to exert an equal pressure over the entire plate, before the steam blows off very sharply and continuously on raising the safety valve. At this point in the molding process the pressure should be increased, but an interval elapse between the turns of the screw in order to allow the celluloid, which flows very slowly, to escape under the pressure. At the end of the process, considerable pressure should be exerted by means of the screw, as much, indeed, as can be applied, or until the screw can no longer be turned. If alcohol is used to generate the heat, the cup of the apparatus is of such a size that its contents are consumed by the time the steam blows off from the safety valve, and the molding is completed. If gas or kerosene is employed, the flame should be so regulated as to complete the molding process within thirty to forty minutes, otherwise the celluloid may be injured.

To mold celluloid in glycerin or oil an apparatus represented by Fig. 1161 is employed. It consists of an open tank to contain the glycerin, with a thermometer to indicate the heat, a stand on detachable legs, and a screw-clamp to hold the flask. In the use of the glycerin apparatus, when the case is ready for molding, the celluloid blank is placed in the flask, which is then put in the screw-clamp, and the screw turned until it lightly presses upon the top of the flask. The whole case is then placed in the tank and sufficient glycerin poured in to cover the flask—about one and a half pounds.

The heat (which may be generated by alcohol, gas, or kerosene) is then applied, and as soon as its effect is felt by the screw yielding to slight pressure, about 225° F., the molding process is commenced. The screw should be very gently turned at first, and the pressure regulated by the softening of the celluloid, and increased as the flask closes. The flask in the clamp can be removed from the tank at times to note the progress of closing of the flask, which should take place evenly, so as to distribute the pressure equally over the entire plate. The heat should not rise above 280° F., and if the flask is not closed completely when this temperature is reached the flame may be reduced. Olive or lard oil may be used instead of glycerin, but the latter is

preferable on account of cleanliness. In using steam or glycerin, the flask should remain in the clamp until it has become cold; the cooling may be hastened by immersing the clamp and flask in cold water. Where the plate is of unusual thickness, or the blank is changed in shape to accommodate it to the case, it is recommended to place the flask, secured in a clamp, near a stove, at a temperature not exceeding 140° F., for at least half a day, in order to avoid the danger of warping the plate. It is also necessary, in the use of the steam apparatus, to put sufficient water in the heater, as too small a quantity may be entirely converted into steam, which is liable to become overheated, a result which is not only dangerous, but injurious to the celluloid.

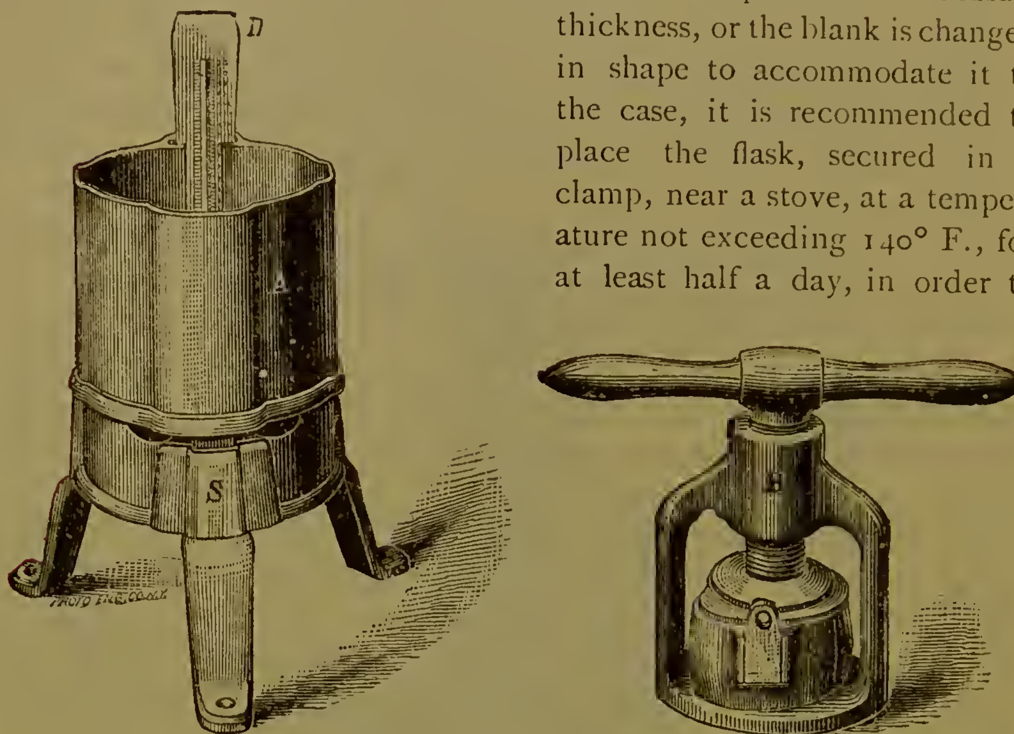


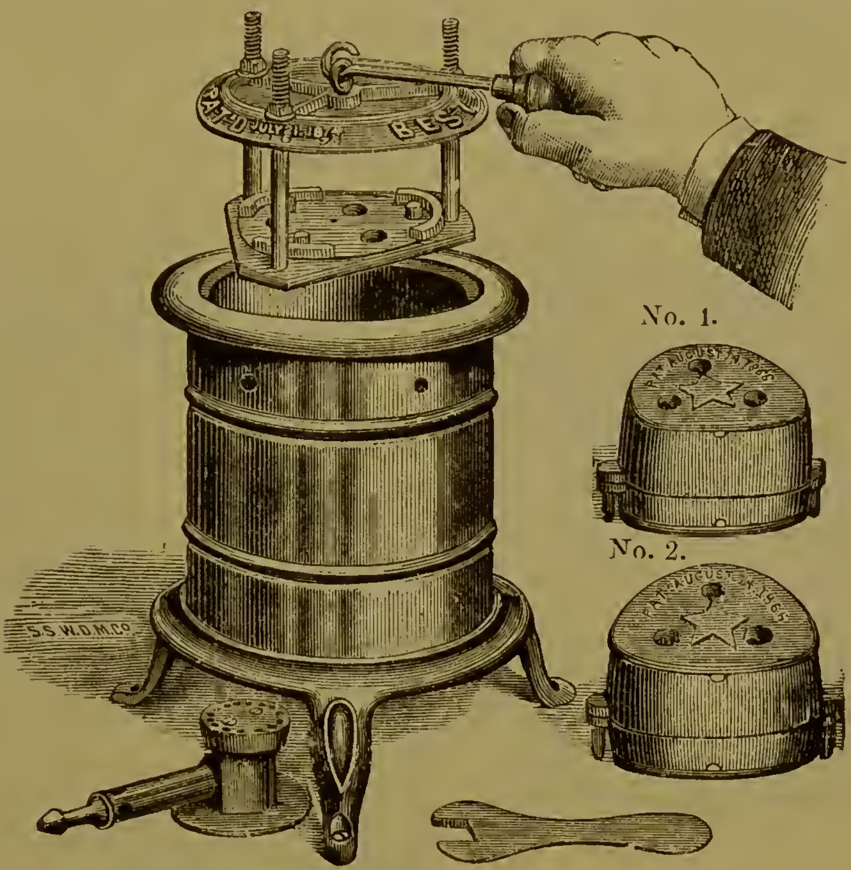
FIG. 1161.

In molding celluloid by means of hot, moist air, several forms of apparatus may be used, one of the most prominent of which is the "Best" Hot Moist Air Celluloid Apparatus, represented in Fig. 1162.

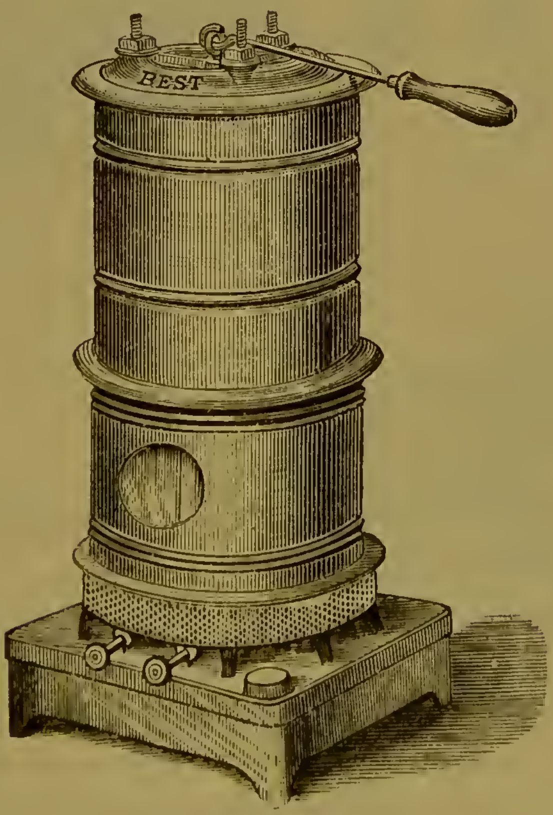
In using the "Best" apparatus, the plaster in the flask should be made very wet by placing it in a flask of water before it is put into the heater. After this is done the flask is placed in the clamp, the top of which is screwed down until it comes in contact with the flask. It is then placed in the oven of the heater and the heat applied, the degree of which is determined by moistening the end of the finger and applying it to the flask. When it fizzles on contact, as a sad-iron does to the finger of a washerwoman, the flask is screwed together.

The point of a knife inserted between the edges of the flask will also determine the condition of the celluloid at this stage; also by experience in screwing down the flask. More pressure is applied as the celluloid softens or flows, allowing some little time to elapse

between the turning of the screws, until the sections of the flask are brought together, when the heat is removed in order to avoid injur-



RIGGED FOR GAS.



RIGGED FOR KEROSENE.

FIG. 1162.

ing the plate by making it porous. In the use of this apparatus the edges of the flask must not be pressed together until the celluloid is sufficiently softened to flow; and, on the other hand, the sections of the flask must not be kept apart too long or the plate will become hard from the evaporation of the camphor and obstruct the proper closing. The case is then removed from the oven of the heater and allowed to cool gradually, until it becomes quite cold.

For molding celluloid by dry heat, which is now considered to be preferable to either steam or glycerin, the New Mode Heater, represented by Fig. 1163, was the first apparatus invented which possessed superior advantages over the others used for the purpose, and also for vulcanizing rubber. It is a cylindrical-cast vessel, having two chambers, one within the other, the inner one being supported by piers or columns connecting its sides, top, and bottom with those of the outer chamber, the whole being made in one casting. The outer compartment is the steam-chamber or boiler, and incloses the hot-air or packing-chamber on all sides except the front, where the walls of the two chambers converge and become one, for the purpose of permitting access to the packing chamber. A door, made of the same metal as the boiler, and fitted with lead packing to make it steam-tight, is held in place by a bridge secured with screws. The door is also provided with a plate-glass light (shown in cut), through which the operator can watch the progress of the molding in the oven. The only communication between the two chambers is by means of a valve having its seat in the top of the packing-chamber, and controlled by a hollow stem which passes through the top of the machine.

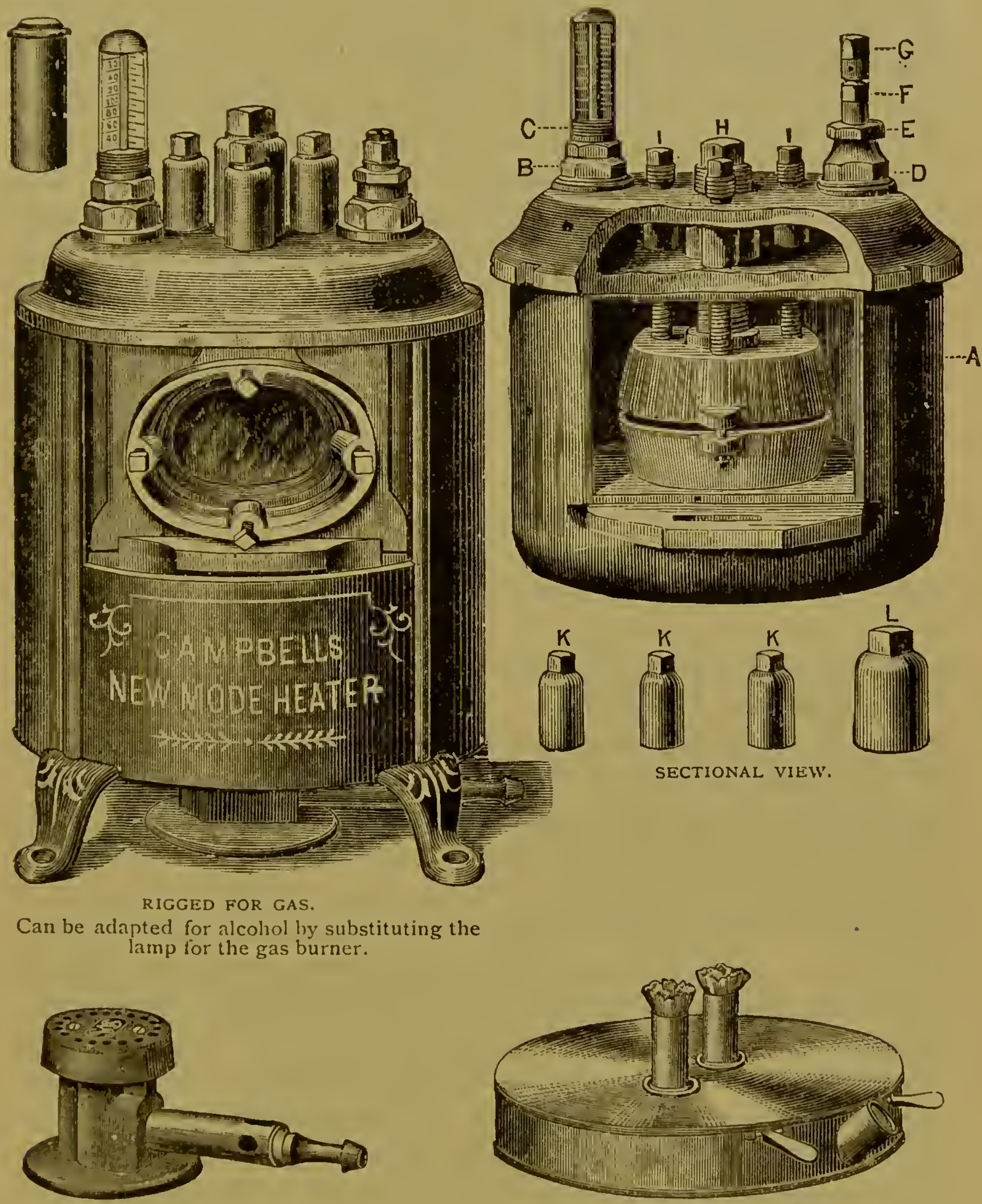
B is a mercury bath; C, thermometer; D, screw plug; E, lamnut; F, stem of steam-valve; G, screw-cap; H, large screw for closing the flask; I, I, I, smaller screws for the same purpose; K, K, K, L, nickle-plated caps for screws; O, O, steam-chamber.

The New Mode Heater, Seabury's and Evans's Vulcanizers (Fig. 1163) combine in one apparatus important improvements in the means of working both celluloid and rubber, that cannot fail to commend them to the favor of the profession.

It is the conviction of the inventors, which is sustained by the experience of many experts in the use of both substances, that *perfect* work in either can only be made in a dry chamber, and that where a high degree of heat is used, such as is absolutely essential in the manipulation of celluloid, the temperature must be kept uniform until the work is complete, and must not be allowed to change suddenly.

Steam is used in these machines to heat up the packing-chamber and investment, but the chamber itself can be, and for certain kinds of work must be, kept absolutely dry after the molding commences,

while the complete control which the operator has over the workings of the machine enables him to maintain the heat at any desired temperature. The hot-box or packing-chamber is nearly, in one, and in the others quite, surrounded by the boiler, and steam may be admitted to



SECTIONAL VIEW.

RIGGED FOR GAS.
Can be adapted for alcohol by substituting the lamp for the gas burner.

GAS BURNER.

ALCOHOL LAMP.

FIG. 1163.

or excluded from the packing-chamber at will. A case may be removed from the heater and another one inserted without reducing the temperature or letting off the steam from the boiler, thus accomplishing a large saving of time. The boiler has no steam-packed plunger or screw

to cause uncertainty as to the amount of pressure applied. The top of the boiler, in the case of the New Mode Heater, is cast in one piece with the boiler; the flask is closed with a small key-wrench by the thumb and finger, the screw-bolts for closing the flask passing through the steam-chamber in piers or columns; a steam-tight plate-glass door permits the operator to examine the work at any time during the process of molding, enabling him to apply the proper pressure at the right time, thus reducing the liability to break the cast, investment, or teeth. The descriptions of the Seabury and Evans machines, in the article on Vulcanite, will explain their manipulation.

Dry heat has no injurious effect on the celluloid material. If a piece of transparent celluloid be passed through a jet of steam, the transparency will disappear in an instant, and the material will become opaque and lose its hardness. A piece of the same transparent celluloid heated in a dry chamber to the same temperature as that of the jet of steam is not affected, its transparency and hardness remaining unchanged. So, too, a piece of black rubber vulcanized by dry heat is of a pure jet-black color when taken out; while a piece of the same black rubber vulcanized in the ordinary method shows brownish discolorations. These simple experiments show conclusively that the action of the steam is the cause of the loss of quality. Dr. Campbell gives the following directions for the molding of celluloid in his apparatus, which are also applicable to the others:—

To secure the best practical results, celluloid should be molded or pressed into the form desired at the highest possible temperature which will not burn it. To prove this it is only necessary to mold a plate on a metal cast at the lowest temperature at which it can be done, which is less than 212°, and another on the same cast at the highest temperature possible, say 310° or 320°, and lay the two aside for a few days, when it will be found that the one molded at the lower temperature will not fit the cast, while that molded at the higher temperature will fit as well as when first made. The reason is that the low temperature fails to overcome the tendency of the plate to return to its original form, while the high temperature renders it so thoroughly plastic that this tendency is entirely eradicated. This is proportionally the case with pieces made at intermediate temperatures; the higher the temperature to which the plate is subjected in molding, the more exactly will it hold its new form and the less will be its tendency to warp.

Celluloid may be readily and safely manipulated in the New Mode Heater at 320°, a temperature many degrees higher than is deemed safe in other machines, and which accomplishes perfectly the result above noted, and produces a plate which is believed to be absolutely

unchangeable in color, form, and texture. When this very high temperature is employed the celluloid should be in the machine only long enough to permit the closing of the flask; for the reason that heat vaporizes the camphor—the solvent of the material. If too much of this is driven off before the flask is closed it will be almost impossible to mold the blank to the desired form. The sooner the flask is closed after being placed in the oven the more readily it will be done and the better will be the result.

The molded surface of a piece of celluloid is much more durable than its interior, and will retain the color better. It is obvious, therefore, that this surface is essential to the integrity of the plate and should be preserved intact. To insure this, the case should be so prepared that the plate, when taken from the flask, will require little or no labor to make it ready for use. It is possible that some surplus material at the edges may have to be trimmed off and the edges smoothed, but the case is not properly prepared if more than this is necessary. The care and trouble involved in proper preparation will really save time, will absolutely avoid interference with the fit by the too free use of files, sand-paper, pumice, etc., and will insure a durable plate with a permanent imitation of gum-color. Moreover, the artistic taste of the operator may be exercised before the plate is molded more readily than afterward.

Paraffin and wax compound is used for the base plate, according to directions before given, and the teeth arranged, the wax carved into the shape desired by means of carving tools, and made smooth. The piece is then invested in plaster, the usual grooves cut, the wax teeth and tin foil being removed with the upper half of the flask in parting. The wax is then removed by means of boiling water, as before described, the tin foil, No. 60, used for covering the paraffin and wax plate remaining upon the plaster, and the investment is now ready to be dried out preparatory to receiving the celluloid.

Drying the Cast and Investment.—To dry a plaster cast and investment, and keep them free from cracks and checks, is very difficult by the ordinary means, but with the New Mode Heater it can be done so perfectly as to permit their use in casting pure gold or gold alloys.

There are two ways of drying the investment in the New Mode Heater: first, by raising the temperature to 320°, keeping the hot box dry; second, by admitting steam to the hot box. The former method can be used when the investment is placed in the chamber before getting up steam. If steam is up, however, either method may be employed. In using the dry heat method, open very slightly the screw cap of the piston or valve stem, to permit the escape of the steam generated from the water in the plaster, being careful that the steam

valve is firmly seated, as otherwise all the steam made in the boiler will escape. In using steam for drying, admit the live steam into the chamber with the investment by raising the valve from its seat, keeping the screw cap closed. The steam quickly permeates the plaster, and in five or ten minutes the temperature of the plaster is high enough to convert the water in it into steam. As soon as the plaster is thoroughly heated, shut off the steam by closing the valve, and raise the screw cap very slightly, to allow that in the chamber to escape slowly through the small aperture at the side of the screw. In a few moments the cast will be perfectly dry, the steam escaping from the chamber, carrying with it that generated from the moisture in the plaster. Extreme care should be taken that the steam shall escape *very slowly*, as otherwise the plaster may be blown out of the flask into the oven by the too rapid expansion of its vaporized moisture. The completion of the drying process is known by steam ceasing to be given off at the screw cap, G. The drying may be facilitated by placing a small chip of wood between the two parts of the flask when it is put into the chamber, thus exposing a larger surface to the heat and allowing the moisture to escape more readily.

Molding by Dry Heat.—When the investment is dried, remove it from the chamber and insert and carefully adjust the selected blank; replace the flask in the oven immediately under the screws; see that the two sections are so placed that the guide-pins will enter properly into the lugs; open the screw cap a turn or two to allow the escape of the gas from the hot box; turn down the large screw until it bears lightly upon the top of the flask, and close the machine. In less than five minutes the material will be sufficiently softened to permit the commencement of the molding. The screws will turn readily with the thumb and finger (using the smaller key-wrench) when the blank is properly softened. Close the flask gradually, stopping occasionally if the resistance is too great. Usually, if the temperature is about 300°. the flask can be closed in ten minutes; but if a very thick blank is used, the molding must proceed slowly; the small screws may be used to advantage, and more time, say thirty minutes, may be consumed. As soon as the flask is closed—unless a lock flask is used—the flame should be extinguished, the door opened, and the machine allowed to cool. If a lock flask is used, it may be removed and thoroughly cooled before opening it, the oven being meanwhile ready for another case. The cooling may be accomplished rapidly, if necessary, by placing the flask in water. When perfectly cold, remove the plate from the investment; it will be found enveloped in the tin foil which had been burnished to the wax plate. Peel off the foil. The celluloid will present a hard, brightly-polished surface, received from its contact

with the foil, *and will need no further finishing than cutting off the excess of material and smoothing down the edges.* The extra hardness of the *surface* will thus remain to preserve the integrity and color of the piece. It is claimed, also, that the contact of the foil renders the outer surface, which is always the densest portion of celluloid, much harder.

Imitating Gum Membrane.—The plate produced by the above method is of the ordinary appearance, with smooth, polished gum, but a much more natural, life-like gum will result if the tin foil, after being burnished to the wax plate, is "stippled." This is done by "dotting" carefully over its surface with a dull-pointed instrument, which should be held nearly perpendicularly to the surface to be operated on, and the strokes should be gentle—*not hard enough to perforate the foil.* When the foil is removed, after the case is molded, the gums present an appearance closely resembling the natural membrane. The stippling need not occupy a great deal of time, and the result it produces is a marked improvement.

Metal Casts and Deep Undercuts.—Many dentists who prefer to use metal casts have doubtless found difficulty in removing the finished plates in cases of deep undercut. The fact that a melted metal cools from the surface toward the center supplies an effectual remedy. When the metal is poured into the sand, allow it to chill only about a quarter of an inch on the outside, and then pour the balance out of the mold. This makes a hollow cast or shell. Fill up the cavity with plaster and proceed as usual. After the plate is molded, remove the plaster, place the edges of the metal cast in the jaws of a vise, and crush the shell. This will free the piece without disturbing the teeth. The plaster in the shell also affords the means of attaching the cast to the articulator. A plaster core in the form of a cross may also be inserted when pouring the metal die in the base, which will divide the core into four sections, which may be crushed together in a vise and thus liberate the celluloid plate.

Repairing.—If a portion of a plate has been broken away and lost, fit a piece of celluloid of the proper shape, leaving it somewhat larger than the space to be filled. Make sure that the surfaces to be united are *perfectly clean;* even the perspiration from the hand may cause a dark line. Flask and mold as usual.

A crack in a plate or the parts of a broken plate may be joined by scraping the surfaces clean, or washing them with alcohol, and molding a thin strip of celluloid into the seam.

The following method of repairing small breaks is suggested by Dr. M. H. Cryer, and possesses the merit of extreme simplicity, and its results are in the highest degree satisfactory:—

Remove all portions of the broken tooth from the plate, taking care

not to disturb the outlines of the socket. Select a tooth of proper size and shade to replace the broken one. (If the tooth is numbered, a considerable part of the trouble of selection may be saved by taking the number of the mold from the reverse impression in the plate or from the broken pieces.) Having set the new tooth partly in its place, hold it steadily over the flame of an alcohol lamp, carefully guarding the celluloid from contact with the flame. In a few seconds the tooth will begin to grow warm, and its heat will soften the celluloid sufficiently to allow the tooth to be pressed into its proper position with a napkin. This will cause a small bulge or raised spot to appear in the celluloid opposite the lingual portion of the root of the tooth. Invest in plaster, in the deeper section of the flask, covering the whole plate and the teeth, except the small portion of the celluloid raised in pressing the tooth into place. Complete the investment, part the flask, and dry the case, after which insert a piece of rather thick writing paper or heavy tin foil over the raised spot and place in the oven. Heat up to the usual temperature for molding and close the flask. When the case is cold the tooth will be found firmly fixed in its position, and there will be no mark to show that the plate has been repaired.

In case a small portion of the celluloid is chipped away from the front of the socket—enough only to expose the end of the root when in position—drop a little wax upon the vacant spot after placing the tooth and carve to the shape desired. Without removing the wax, invest and mold as before described. The wax will pass off into the plaster and its place will be supplied by the celluloid, of which there is usually enough to permit the flowing of the minute quantity required without damage.

If there is a similar deficiency on the inside of the plate, exposing the pins of the tooth, drop wax into the vacancy and proceed as before, except that in this case the wax is to be removed when the investment is made, and the bit of writing paper or tin foil is to be placed just below the pins, instead of over them, so as to force the flowing of the celluloid to cover them.

To remove a tooth from a celluloid plate, *hold* the outside surface of the tooth to be removed in the flame of the lamp until the heat softens the celluloid around the pins slightly, when it may be taken off without trouble, and it will come away clean, without any of the celluloid adhering to the pins. Do not move the plate back and forth through the flame, or other teeth than the one desired may be loosened, or their perfect articulation may be interfered with. There is no danger of cracking the tooth so long as the flame does not come in contact with the pins.

Fig. 1164 represents the first process in repairing a celluloid plate from which a tooth or block has been broken. The plate being cut away sufficiently to allow the new tooth to be adjusted by grinding, a new piece of celluloid (*a*) is fitted to the space. The new piece is then removed and its place filled up with wax. Fig. 1165 shows the piece invested in the lower section of the flask, the space filled with wax being the only portion visible, the entire surfaces of the plate and teeth being covered. The upper section of the flask is then adjusted and filled up with plaster. When the flask is opened the wax is removed and the new piece of celluloid returned to its place, and upon it is placed another small piece of celluloid, or a roll of tin foil, to produce pressure upon the new piece first added, the edges of which, as well as those of the space into which it is fitted, being moistened with spirits of camphor or liquid celluloid to bring about union.

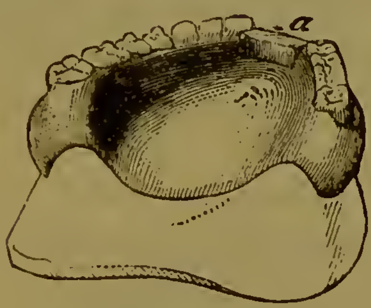


FIG. 1164.

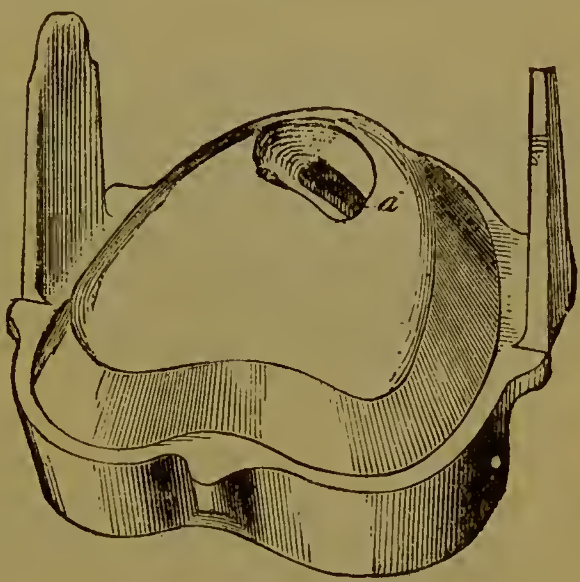


FIG. 1165.

Liquid celluloid is made by dissolving small pieces of celluloid in spirits of camphor. The piece is then placed in the heater and subjected to the usual process. Where the plate is of considerable thickness, a new tooth or block may be added without new material by cutting away as little as possible of the old plate on the lingual surface, and depending upon the thickness of celluloid pressing up, after being softened in the heater, closely to the new tooth. Loose teeth may be tightened in the same manner, wax being introduced into the vacant space and removed after the flasking.

Some object to the use of a solvent in repairing on account of the liability of the newly-added material to become porous. To cleanse celluloid plates previous to repairing, they should be placed in a solution of whiting and water, to which is added some liquid ammonia, and allowed to remain some time, when they are brushed with soap and water, and finally washed in clean water and dried.

NEW MODE CONTINUOUS GUM.

With reference to the second objection to the use of rubber, it is to be said that the perfect reproduction of natural effects and really artistic work cannot be made with block teeth. To obtain the proper expression, each tooth should be available for placing in any position desired, instead of being arbitrarily held in association with others, as in a block.

The invention of the New Mode machine places in the hands of the profession the means for overcoming this objection by using plain teeth with rubber for the base, and celluloid, which is well suited for the purpose, for the gum, the combination forming an exquisite piece of work which the inventor calls the "New Mode Continuous Gum." It is easily the nearest approach to porcelain continuous gum that has been obtained with plastic materials. Its general adoption would do away with "bad joints" and broken blocks, which are so often a source of serious annoyance. It is the only rubber plate upon which a tooth may be replaced without revulcanization, and which after the repair is equal in strength and appearance to the original piece; and the only one upon which repairs can be repeated any number of times without injury to the original plate. This same style of work can also be done with gold and with cast-alloy plates.

Directions for Making the New Mode Continuous Gum.—Using teeth made expressly for continuous-gum or celluloid work, set them up in wax in the usual manner, leaving the front or outside of the roots exposed. Cut a thin strip of the wax, warm it, and attach it to the upper edge of the portion of the wax plate representing the gum, forming a rim which extends all around the outer margin. Finish the palatine surface to the form desired, invest in the flask in the usual manner, remove the wax, pack with rubber, and vulcanize. When removed from the flask the case will present the appearance shown in Fig. 1167, the front or outside of the roots being exposed and the narrow *undercut* rim extending all around, leaving a space with retaining grooves between the teeth for forming a gum of celluloid, looking very much as though the substance of the plate had been gouged out for the purpose. The vulcanite plate is now completed with the teeth firmly attached to it.

To put on the gum, fill up the groove with paraffin and wax (this compound, not being sticky, does not adhere to the instrument and is therefore more easily carved to the form desired) until all the space inside the rim, including the retaining grooves between the necks of the teeth, is occupied. After the wax has hardened, which may be hastened by placing in cold water, carve it into the desired form of

FIG. 1166.

FIG. 1167.

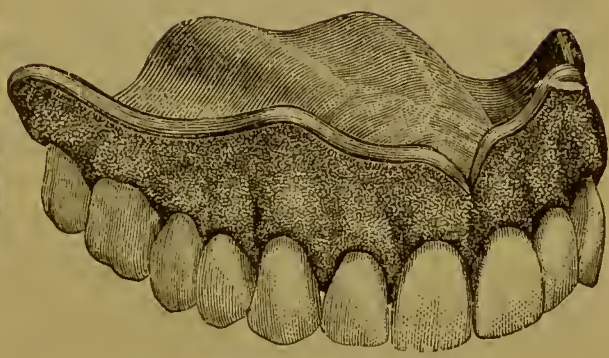


FIG. 1168.

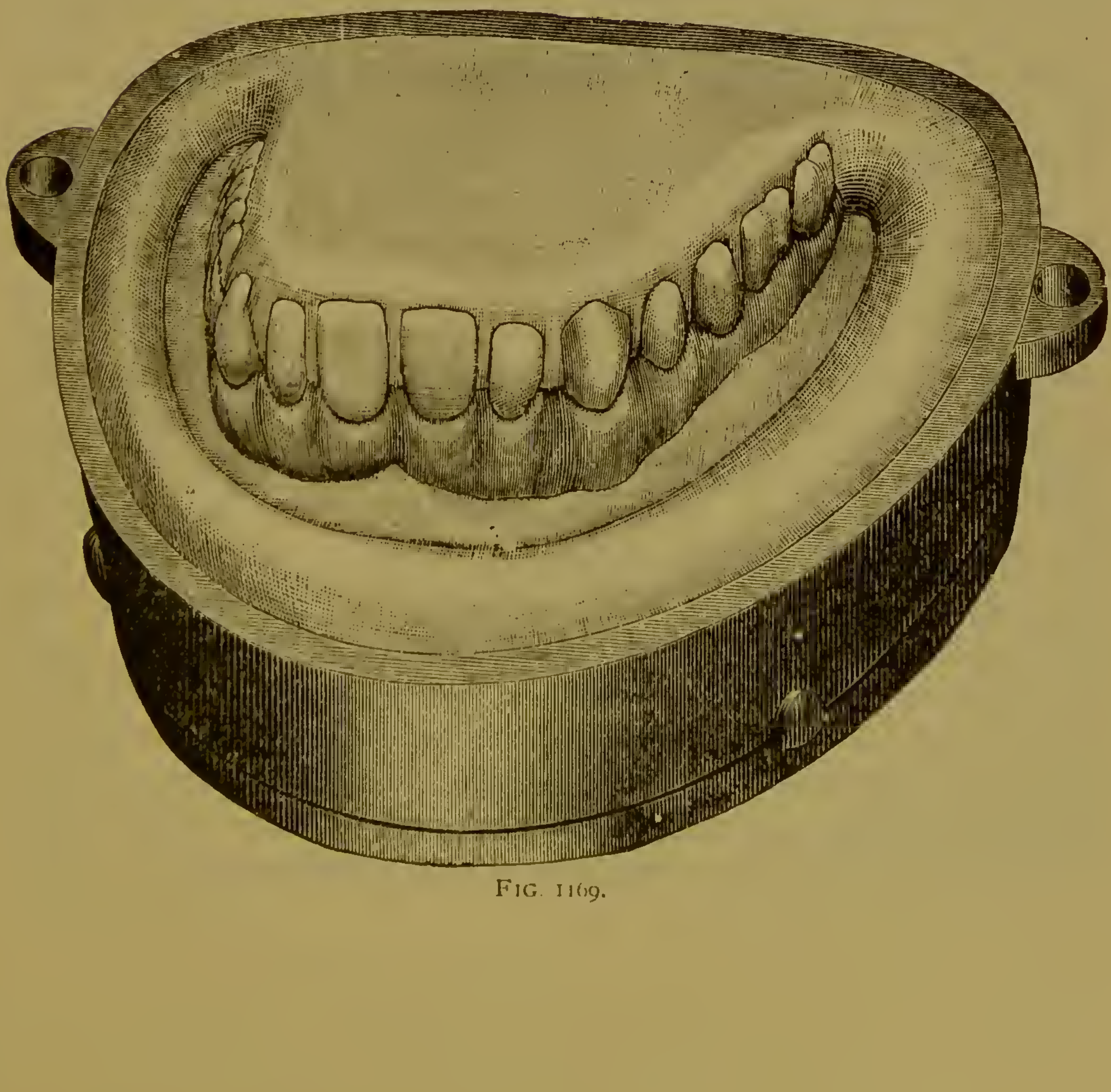


FIG. 1169.

gum. The wax may be made very smooth by throwing upon it the flame of a spirit lamp with the aid of a blowpipe, taking care not to destroy the outline of the carved gum. Cover the wax with heavy tin foil, burnishing it lightly but smoothly to the wax.

Invest the piece again in the following manner: Place the plate in one section of the flask with the teeth upward, and raised at the front at a greater or less angle, as may be necessary, so that when the investment is completed the upper part of the flask may be removed without dragging. Imbed in plaster to the rim and pour plaster over the palatine surface covering the crowns, and taking care to fill the interstices between the necks of the teeth, but leaving their outer surfaces exposed. After the investment sets, pour more plaster around the inner edge of the flask ring, forming a ridge, leaving a groove or space between it and the plate. (See Fig. 1169.) Complete the investment and remove the wax from the groove and interstices between the roots of the teeth by pouring boiling water over it. Having selected a celluloid blank of proper size, saw off the outer rim (see Fig. 1166); warm this rim of celluloid in boiling water, and with the hand and a cloth press it closely about the teeth and hold it to its place until stiff; it will then remain there until the two parts of the flask are entered upon the guide-pins. Join the two parts of the flask together and place the investment in the oven of the machine, having previously heated up the chamber. When the temperature of 280° is reached the flask may be closed. As soon as this is accomplished the case is ready to be removed from the oven and placed in a clamp to cool.

When perfectly cold remove the plate. The tin foil will adhere to it, but it can be readily removed by inserting the point of a knife under the edge and pulling it off, leaving the surface of the celluloid gum as smooth and polished as that of the foil.

A surface produced by the above method presents a smooth, polished gum, but if the tin foil is "stippled," as before described, a striking resemblance to the natural membrane will be produced, the finished plate presenting the appearance shown in Fig. 1168. The adjoining edges of the celluloid and rubber will be found perfectly united, each preserving its sharp outline.

Dr. D. Genese recommends the following method of working celluloid, which will give a hard, smooth, polished surface to the plate when it leaves the heater, regulate the size of the celluloid blank before it is molded to the surface of the metal die or cast and about the teeth, and also form a metal cast, which is easily removed from the celluloid plate after it is completed:—

Two perfect impressions in plaster are taken of the mouth, one of

which is used to secure a plaster model, upon which the trial plate is formed, of wax and paraffin. Upon this trial plate a rim of wax is built, and the exact bite secured. In wax, only the model of the piece desired in the finished case is then formed, which is attached to a metal die, which has been obtained by molding the plaster model in sand. The whole is then molded in sand, and a zinc and lead die and counter-die obtained, by means of which a tin cap (made of rolled tin, No. 29 gauge) is swaged, which will completely envelop the wax model, extend over the gum portion, and to the full height of the finished "bite." The edge of the tin cap, which is left rough, is turned up at an angle of about forty-five degrees, so as to form a support for it in the plaster, when it is invested. The object of this cap is to form a metal mold in which the celluloid blank can be shaped to the form and size desired for the case in hand. The modeled wax is then transferred to the plaster model, which is invested in the lower half of the flask, and the surface of the investment varnished over and oiled, to ensure the required separation. The tin cap is then placed over the modeled wax surface and the upper half of the flask filled with plaster. When the flask is separated, the wax is removed from the plaster model, the tin cap remaining firmly secured in the upper half of the flask. The celluloid blank is then placed in the tin cap mold, and the sections of the flask brought together by being placed in a heater. Upon removing the blank from the mold, in the flask, any excess of celluloid can be removed, and a blank of a proper size and form secured which will not press the teeth out of position in the subsequent molding of the plate. It is necessary to secure a duplicate bite to mount the teeth, which is done on a metal die or cast, formed as follows:—

The second plaster impression is removed from the impression cup and imbedded in a sand and plaster investment as deep as it is desired to have the cast. A right-angle cross, with arms about half an inch wide at the upper surface and tapering to a sharp edge (Δ), is then made of plaster mixed with sand and placed over the surface of the plaster impression in such a manner as to bring the sharp edge almost, but not quite, in contact with the impression surface, where it is secured by sealing the ends of the arms to the margin of the impression. A metal die or cast made in this manner is divided into four sections by the cross-core, very nearly to its surface, and is more readily removed from the celluloid plate after it is molded than the hollow metal cast, as the removal of the plaster core will permit of the sections of the cast being bent away from any undercuts which may exist. After obtaining the form of metal die described, the teeth are mounted upon a trial plate formed over it and according to the duplicate

"bite," and the new wax plate is modeled into the form desired for the finished celluloid plate. An impression in sand of the whole is again obtained, a zinc die and lead counter-die poured, and a tin cap similar to the one first made is swaged. This tin cap forms a complete metal casing, and on flasking, is secured in the upper half of the flask by means of its turned edges. The case is then flasked in the usual manner, and on separating the sections and removing the wax the celluloid blank, which has been previously molded into form, according to the manner described above, will be found well adapted to the mold. The case is then placed in one of the combination heaters and molded at a temperature of 300°, which should never be exceeded; and no pressure should be applied by the screws until this heat is obtained. The construction of partial sets is more difficult, but the process is the same as for entire dentures, a cap of somewhat lighter tin being used. By this process the edge only of the plate and a slight excess of material about the necks of the teeth require trimming off, the entire surface being polished without any scraping away by first using fine pumice and glycerin, and finally whiting and glycerin. The plate should be thoroughly cleansed, after removing it from the flask, of all particles of plaster that may adhere to it, and the entire manipulation be conducted with clean hands and instruments.

A metal cast somewhat similar to the one above described may be made by first molding in the usual manner, and afterward sawing all around the alveolar ridge with a fine saw, leaving only what will hold the parts together. Plaster is poured into the spaces made by the saw, in order to render the cast solid. When the set is finished the plaster is removed from the spaces and pressure made by a vise upon the edges of the cast, so as to crush them in and thus free the plate.

Dr. M. H. Cryer devised the filing of notches in celluloid blanks as in Fig. 1170, when the countersunk tooth-crowns are to be mounted in this material. The suggestion obviates the defects found to attend the mounting of these teeth in the usual way, for the confined air in the cups commonly prevents the celluloid from entering far enough to more than half fill them, and thus the pins are left untouched. As a consequence the teeth come off in the process of finishing; or, Fig. 1171 shows the effectiveness of the plan which provides for the escape of the air, while the plastic promontories enter the countersinks and surround the pins, by means of which the teeth are firmly secured to the plate, on which they thus have so strong a hold that the labial necks of the crowns may, for conformity to the adjacent natural teeth, be quite uncovered by the celluloid (see Fig. 1172), and the mounting be yet a strong one, as is evidenced by the section through plate and crown, Fig. 1173, which illustrates a countersunk tooth

crown. In this instance the short celluloid festoons (see Fig. 1172) lie close upon the gum, which they much more nearly resemble than the dark vulcanite when such a base is made.

When the celluloid blanks are molded upon plaster surfaces, files, scrapers, and fine sand or emery paper are necessary in the finishing process, completing the operation of polishing with whiting or prepared chalk, applied by means of a soft brush wheel. Camphor, applied on a soft cloth, is also used to obtain a polish, especially between the teeth and other places beyond the reach of the brush wheel. Friction with the brush wheel sufficient to heat the plate should be avoided, on account of the danger of changing the shape of the plate and injuring the surface. Dark lines on celluloid plates are often the result of using blanks too wide for the case or too thin in the center, causing

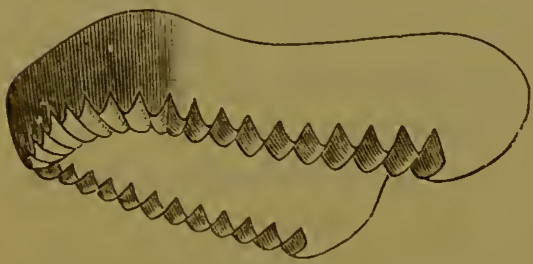


FIG. 1170.

FIG. 1171.

FIG. 1172.

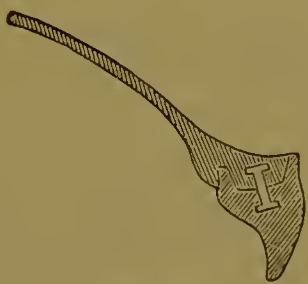


FIG. 1173.

the celluloid to press toward the middle of the plate and fold upon itself. Where the arch of the mouth is very deep, the pressure by means of screws should not be applied before the blank is well softened by the heat, otherwise it may tear apart. Too little pressure, or too little material, may cause a porous plate; also overheating in the dry heat apparatus; the same condition in steam heating may result from too little pressure at the proper time. If the temperature of a celluloid plate is raised to 270°, without any pressure being brought to bear upon it, the material becomes puffed up and is ruined in texture, and cannot be restored by any subsequent manipulation. Celluloid flows very sluggishly, hence sufficient material must be present to insure a perfect plate. The celluloid blank may be softened in boiling water and formed into any desired shape, and an excess at any point may be removed with a sharp knife. It should be remembered that there is no

union between celluloid and rubber, hence when one of these materials is added to the other, it can only be done by dovetailing or drilling holes. Good, hard-setting plaster should always be used in working celluloid, and it should be well mixed by adding it to the water in such a manner that all is absorbed that it will take up. Care should also be taken not to mix the plaster too thin or to use very fine plaster, as a coarse grade of strong plaster will give better results. Some are in the habit of adding clean white sand or marble dust to the plaster. The following directions are given in the use of the New Mode Heater, which will prove serviceable in the working of celluloid generally:—

Always use good plaster, and do not mix too thin; always select a blank which nearly fits the cast, with an excess in *every part;* always turn the screws as soon as they will yield to the thumb and finger, and *always* gently; always follow up the rise in temperature with increased pressure; always give the material plenty of time to flow between the turns; always increase the pressure toward the close of the molding; always reduce the temperature of the piece at once after the completion of the molding, and keep the plate under pressure until it is stone cold.

ZYLONITE.

A modified form of celluloid has been introduced under the name of *zylonite,* the working results of which appear to show a great difference in quality. Zylonite, like celluloid, is composed of pyroxylin and camphor, but in different proportions, being, it is claimed, a chemical combination, while celluloid is a mechanical mixture.

Possessing translucency, the effect of zylonite in the mouth is very pleasing, and, so far as it has been tested, promises to be more durable than celluloid, without the tendency to warp or to change color when ordinary care is taken in its manipulation, which is the same as for celluloid. The zylonite blanks are uniform in color, and although this material requires the same amount of pressure to mold, it flows with a more perfect sharpness of outline than celluloid, and apparently does not disintegrate.

CHAPTER XVI.

PORCELAIN TEETH.

As Pharmacy was once a part of Medical Practice, and instrument-making a part of Surgery, so the manufacture of porcelain teeth was at one time confined to the dental laboratory. Until within the past forty years a practical knowledge of the Dento-ceramic art was con-

sidered an essential part of dental education. Galen compounded his celebrated *Theriaca* for two Roman emperors; Paré and Wiseman made many of their surgical instruments; and necessity has compelled physicians and surgeons in all ages to imitate these examples. But the medical and surgical world have for many years committed the manufacture of drugs and instruments to those who, by making it a special art, can produce far better results.

The time has fully come when Dentistry has done the same with porcelain work, for two sufficient reasons: 1. Manufacturers now offer to the profession porcelain teeth in such variety of beautiful forms that not one dentist in a thousand could equal them. 2. Moderate proficiency in block-carving requires such an amount of preparatory training and of continuous experience, that the dentist's education and practice must suffer in the line of important duties which cannot thus be delegated to others. Hence, nearly, if not quite all, of the most skillful block-carvers engaged in the practice of dentistry have, since the year 1850, one after another, given up this art, which it cost them so much to acquire. For these reasons, and also because the management of a porcelain furnace cannot be taught in books, we shall not attempt in this chapter to give a full and didactic exposition of the manner of making porcelain block or single teeth. Those who desire such knowledge with a view to making it a specialty, require that which no longer comes within the scope of a work on the "Principles and Practice of Dentistry" to teach.

There is, however, on the part of all students, and probably of most practitioners, a desire to know the composition of dental porcelain, and to have some idea of the manner in which a few earthy materials and metallic oxids are made to assume such beautiful forms. Some knowledge of the component parts of porcelain is essential to a correct understanding of the necessity for their admixture, as well as of the effects thus produced.

PORCELAIN MATERIALS.

The infusible earths, Silica and Alumina, and the fusible alkalies, Potassa and Soda, form the bulk of all porcelain. Certain metallic oxids, in small quantity, give color, and some varieties of pottery are modified by small proportions of Lime and Magnesia. Dental porcelain is made from the purest compounds of silica, alumina, and potassa, colored by metallic Gold and Platina, and by the oxids of Gold, Titanium. Manganese, Cobalt, and Uranium.

SILICA.

Silica (quartz, silex, silicic acid) is, next to oxygen, the most universally diffused substance in nature, constituting 50 per cent. of all rocks. Granite, granitic rocks, sandstones, and sand contain not less than three-fourths silica; mica, schist, clay-slate and clay, not less than two-thirds; trap-rocks and lava, one-half. Silica is to the mineral kingdom what carbon is to the vegetable—the element of stability. In its purest forms (rock crystal, Brazilian pebbles, or crystals of quartz), it is free from discoloration by iron or other oxids, it is absolutely infusible, and is insoluble in water; this is the kind selected for dental porcelain, but for other varieties of porcelain flint is commonly used. It forms silicates with alumina, magnesia, lime, potassa, and soda, the most important of which, in this connection, are the silicates of alumina and potassa. Silica, as found in feldspar and kaolin, is partly pure silica, partly the silicate of alumina. Now the "behavior" in the furnace of silica and the silicate of alumina is different; hence, chemical analysis can estimate only the relative purity of these substances; experiment alone can determine the proportions of each necessary for the development of any required property in porcelain.

FELDSPAR.

Next to silica, alumina (oxid of aluminium) is the most universally diffused of all minerals; but, unlike silica, it is rarely found uncombined. The gem Sapphire is pure crystallized aluminium, and is the next hardest mineral to the diamond; a less pure form is well known in dentistry as emery or corundum, some specimens of which seem, under the lens, to be a collection of minute crystals of dark-colored sapphire. For porcelain manufacture, aluminium is never used in its purest state, but in its natural combinations with silica, lime, potassa, and soda. For dental porcelain only two of these are used—Feldspar (known to the Chinese as Pe-tun-tse) and Kaolin. Feldspar is a silicate of aluminium and potassa, containing a little lime and a trace of iron. A less common variety of spar contains soda in the place of potassa; it makes a soft porcelain, fusible at lower heat than the potash spar. Lime feldspar is used in some kinds of pottery, but for dental purposes potash feldspar is the only variety. It is an abundant mineral, and is often found in large masses; the purest varieties alone are used for dental porcelain. Delaware and Pennsylvania spars are most esteemed by American manufacturers. Its most extensive dissemination, however, is as one of the components of granite and granitic rocks, by disintegration of the feldspathic constituents of which large beds of porcelain clay are formed, as found in

China and Japan, England, Germany, and France, and also in the United States.

KAOLIN.—Ka-o-lin (the Chinese word for clay) is the purest of these mixtures of silica and silicate of alumina, prepared in Nature's laboratory for the manufacture of porcelain. Pipe clay, potter's clay, blue clay, fire clay, and Cornish stone are similar in composition, but only the purest kaolin is used for dental porcelain. It contains nine parts of silica and eight parts aluminium; whereas spar has nine parts silica and only two parts aluminium; also spar is made fusible by its silicate of potassa—kaolin has none. Kaolin is, therefore, feldspar deprived of its soluble silicate of potassa (or soda), which has been washed out during the disintegration of the feldspathic rock. It is soft and unctuous, and is highly plastic; pulverized spar on the contrary, is granular or powdery, and is molded with difficulty. Kaolin, like silex, is infusible; under intense and continued heat it shrinks greatly and becomes extremely hard, but it is always porous and absorbent. Silex lessens the contraction of kaolin, spar gives it fusibility; both diminish its absorbent quality, so objectionable in any material that is to be worn in the mouth.

Stone ware, China ware, Wedgwood ware, Parian porcelain, and Dental porcelain vary in their properties because of the different proportions in which kaolin and feldspar are combined, also in the kind of flux used. For instance, the Parian statuettes have kaolin and spar in equal proportions, with about half as much of a flux, made of spar, quartz, and potash. Dental porcelain, demanding less heat, less shrinkage, and a more translucent appearance, has a very much greater proportion of spar. It has required a very extended series of experiments to combine silica, aluminium, and potassa in correct proportions, and to know just which of Nature's compounds it is best to use in order to harmonize the requisites of strength and beauty, so essential to the character of a porcelain tooth.

COLORING MATERIALS.

The foregoing materials give a pure white porcelain of greater or less translucency. It is now required to find substances which will, in the strong heat of the furnace, yield indestructible colors, by skillful combination of which the porcelain may imitate the almost endless varieties of tint in the natural teeth and gum. Of these there are three principal colors and three subordinate ones.

TITANIUM.—The purest varieties of the oxid of titanium are selected; it is found as a mineral in various localities throughout the United States. The crystals are reddish-brown, and have a bright, metallic lustre; they give, when ground, a beautiful yellow, or yellow-

ish-brown color. It is used in the coloring of all *body*, and is the basis of color for the class of yellowish *enamels*.

PLATINUM.—This metal, precipitated from its solution in aqua regia, then washed and dried, is known as platina sponge. It gives a gray-blue color, and is the basis of color for the class of grayish-blue enamels.

GOLD.—Gold precipitate is used to give life and animation to the tooth, producing often a very remarkable effect. The oxid of gold, known as *Purple of Cassius*, and generally considered to be a mixed oxid of gold and tin, is used to impart the well-known red color of the artificial gum; no less costly substitute has ever been found for this purpose.

Oxid of Manganese gives a purplish color, and is used occasionally for some shade of tooth, but not of gum. *Oxid of Cobalt* gives a bright blue color. If wrapped in best blue paper and burned in a covered crucible it is called the ashes of cobalt, and is thought to give a more desirable tint to the enamel than the simple oxid. *Oxid of Uranium* is used in its mineral form and gives a greenish-yellow color; while a lemon-yellow color may be given by the *oxid of silver;* but this is a fugitive color at high temperatures.

These colors, singly and in combination with each other, produce a great variety of colors or shades. Thus, say forty shades of *body color* are made by using these materials in different quantities and in different combinations; also a like number of *enamel colors*. Then, starting with the lightest shade of body, forty different grades may be produced by using a different point enamel; so of each of the forty shades of the body, making, if required, sixteen hundred variations of shade.

The following formulæ will suffice to give a correct idea of the proportions in which the preceding materials are combined to give the BODY and ENAMEL of porcelain teeth, single or in sections:—

BODY.		ENAMEL.	
Feldspar,	12 oz.	Feldspar,	3 oz.
Quartz,	2 oz.	Sponge platina,	1 to 4 grs.
Kaolin,	15 dwts.	Flux,	3 dwts.
Titanium,	24 to 48 grs.		

The FLUX here mentioned is made by fusing four ounces of finely ground quartz with Glass of Borax and Sal Tartar, each one ounce; it forms a transparent glass. The following formulæ show the preparation of Gum Enamel:—

GUM FRIT.		GUM ENAMEL.	
Oxid of gold,	10 grs.	Gum frit,	1 oz.
Feldspar,	1 oz.	Feldspar,	3 oz.
Flux,	8 dwts.		

The titanium, platina, and oxid of gold must, in these recipes, of course, be modified by mixture with other colors to produce the requisite varieties of shade.

BODY FOR MOLDED BLOCK TEETH.

NO. 1.		NO. 2.	
Kaolin,	1 oz.	German clay,	½ oz.
Silica,	3 oz.	Silica,	3 oz.
Feldspar,	18 oz.	Feldspar,	18 oz.
Oxid of titanium,	65 grs.	Oxid of titanium,	65 grs.
Starch,	10 grs. to each ounce.	Starch,	10 grs. to each ounce.

BODY FOR CARVED BLOCKS.

NO. 1.		NO. 2.	
Kaolin,	1 oz.	German clay,	½ oz.
Silica,	3½ oz.	Silica,	3½ oz.
Feldspar,	14 oz.	Feldspar,	14 oz.
Oxid of titanium,	40 grs.	Oxid of titanium,	40 grs.

BLUE ENAMEL.		YELLOW ENAMEL.	
Platinum blue frit,	1 gr.	Titanium,	1 gr.
Feldspar,	1 oz.	Gold frit,	2 grs.
Starch,	15 grs.	Starch,	15 grs.
		Feldspar,	1 oz.

We shall now briefly describe the processes by which the porcelain teeth and sections sold to the profession are manufactured.

PROCESS OF MANUFACTURE.

The silex and feldspar, in their crude state, are first submitted to a red heat, then suddenly thrown into cold water. This is called "Calcining," and the effect is to render them more easily broken and pulverized. All impurities having been carefully removed, they are crushed between flint stones; when fine enough, they are put into a mill, formed of burr millstone, with chasers of the same material. They are ground in water, then floated off, and allowed to settle. The water is then drawn off or evaporated; the silex and spar, dried and sifted, are then ready for use. The kaolin, having been already pulverized in Nature's laboratory, is prepared by washing until perfectly free from impurities, and when dry is ready for use. The flux and frit are coarsely ground, but the coloring materials are reduced to an impalpable powder. All these porcelain materials are combined in proper proportions to form the body and the enamel, then mixed with water and worked into masses resembling putty. When, however, the method of *biscuiting* is adopted the enamels are mixed in a much thinner state than the body.

The unbaked porcelain masses are now ready for the molding room. The molds in which single teeth or sections are formed are made of

brass and are in two pieces—one-half of the tooth being represented on either side. The precise shapes desired are carved out with great care; holes are drilled to receive the platina pins in each tooth; when the two halves are fitted accurately together, with guiding pins for exact closure, the mold is ready for use. The brass matrix must be made about one-fifth larger than the size desired, to allow for shrinkage of the porcelain paste. After greasing the molds, the first operation is, by means of small tweezers, to place the platina pins in the holes made for them (there are many sizes of these pins, differing in length and thickness, to suit the sizes of the teeth). As no piece of mechanism can be stronger than its weakest point, there should always be such a relation between the tooth substance and the pins, as to shape, size, and angle of insertion, that one will be as strong as the other, and both sufficient for all legitimate uses. The strength of pin, without loss of strength in the tooth, characterizes a recent and valuable improvement made by the late Dr. S. S. White, and known as the "foot-shaped pin," illustrated in Fig. 1174. The thickest part of this pin is at the angle, or heel; the point, or toe, runs upward

FIG. 1174.

into the thick part of the tooth, giving additional security against its being drawn out. The insertion of the pin at an upward angle beds it in the strongest portion of the tooth material; thus any weakening of the thin portion of the tooth is avoided, as when the headed pin is inserted in a straight line; also, the greatest amount of material is found where the greatest strain is brought to bear upon it. The force of mastication is exerted outward and toward the necks of the teeth; thus the shape and direction of this pin are best calculated directly to oppose it. It will also be noticed that its direction and unusual length of insertion permit a close grinding of the tooth, which would cause the usual short and horizontal pin very soon to break away from the porcelain. The double-headed pin, a previous patented invention of Dr. White, was a very great improvement in the shape of tooth pins; but it has been superseded by this new "foot-shaped pin."

Fig. 1175 represents both plain and sectional gum teeth with the lateral or cross-pins, devised by Dr. C. H. Land, which, it is claimed, give greater strength to the completed denture than when teeth with the ordinary pins are used. For continuous-gum teeth a complete

arch is formed by twisting or soldering the pins together, thus lessening the strain upon any single tooth, and allowing a much lighter plate to be used. What are styled "countersunk teeth" are also manufactured, in which the pins are attached to the teeth in a depression or cavity formed in the base of each tooth. (See Dr. Cryer's method of mounting, in chapter on Celluloid.)

The pins being properly adjusted, the enamels for the tooth and the gum are placed in the molds by means of a small steel spatula, carefully placing them in the exact position and quantity required; the body is placed in them in lumps corresponding to the size of the teeth; the top of the mold is then put on and the matrix placed under a press, which compacts each separate mass. They are then dried by a slow heat. When perfectly dry the top is removed, and the teeth will now drop out. In this state they are extremely tender, owing to the large percentage of feldspar, and require very careful handling.

Ther are now sent to the trimmer's room, where each tooth is care-

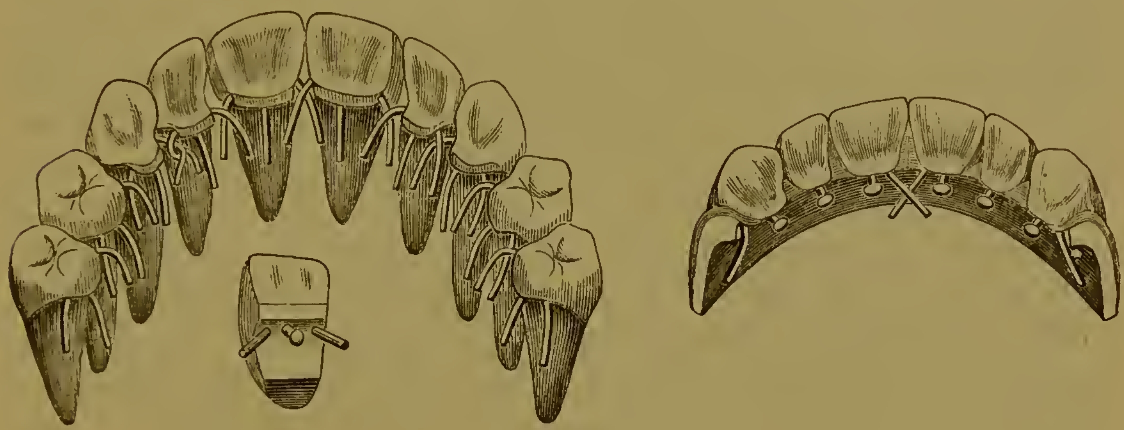


FIG. 1175.

fully inspected and all imperfections removed or filled up; the spare edges left by the union of the two sides of the mold are smoothly filed, and the arch of the gum over each tooth made rounding and true with a small pointed instrument. They are then placed on beds of coarse quartz sand, on trays or slides made of fire-clay, and are ready for the furnace. Formerly there was another process, called crucing, or biscuiting, which was universally practiced, and is still used in some factories; it is also used in the making of blocks carved to order. It consists in submitting the teeth after molding to a heat sufficient to harden them so they can be cut or filed like chalk, and what is called an *outside enamel* is then applied with a camel's-hair brush; but it has been found that the composition of the tooth is injuriously affected by this partial burning, subsequent cooling, enameling, and reburning. This process is unavoidable when the blocks are carved by hand for special cases; but whenever they can be made in a matrix, the tooth is

better and stronger when it is enameled in the mold and finished in a single firing.

The furnace is built substantially on the principle of the dentists' furnace (Fig. 1096), differing chiefly in size. The trays holding the teeth are placed in the muffle, and are thus protected against injury from the gases of the fuel. There is no rule which can be given to determine the exact amount of time the teeth must remain in the furnace; the practiced eye of the burner must determine from the appearance of the teeth when the firing is completed. If taken out before they are done the enamel will craze, or crack, in cooling; if a little too much done, the surface will be too glassy and the body will not be strong. When cool the teeth are removed from the slides, placed upon wax cards, and are then ready for the dentist.

The vast variety in shape, size, color, etc., of the teeth thus made gives opportunity for the selection of forms suitable to nearly every case which presents itself to the practitioner. The assortment must of necessity be very large and varied to meet the wants of the operator; in fact, the manufacturer has shown a better appreciation of the esthetic requirements of the dental art than the practitioner. While the work of the latter too often exhibits an unmeaning monotony, the former has made provision for even the extreme cases which are sometimes met with; he has also given a beautiful series of those various deviations from a uniform regularity which are so common in natural dentures. In some mouths these seem to be imperatively demanded to restore the familiar expression, while in any mouth the use of some one or other of them would go far to disarm that suspicion of artificiality detection of which is mortifying to most patients.

Porcelain is a material in which the beauty of the result well repays the highest exercise of Art. It has been for centuries a favorite material for expressing the Poetry of Form. The famous Etruscan vases of antiquity, the exquisite gems of the *Majolica* of the sixteenth century, the marvelous work of Bernard Palissy, the prince of potters, the beautiful productions of the Sèvres and Dresden manufactories, the well-known charming designs of the Wedgwood ware, and the still more recent Parian statuettes, may be named in proof of the fitness of porcelain to embody the conceptions of Genius. Dental porcelain is worthy of such associations; not only like them does it delight the eye and give evidence of high esthetic cultivation, but it adds to beauty the charm of usefulness. It is customary to attribute the rapid growth of Dental Art, since 1840, to its associations, colleges, journals, and its didactic literature—and with much truth. But to porcelain it owes its very existence as an esthetic art, and the larger

part of its extent and utility as a prosthetic art. It was altogether impossible for perishable human teeth, or their wretched imitations in ivory, to offer such tempting fac-similes of nature as we meet in porcelain. By thus creating that enormously increased demand for dental service which has been the chief cause of the rapid development of its resources, it has made the dental profession its debtor to a greater extent than any other single influence. The depot not only renders service by the superior excellence of the surgical instruments and prosthetic materials which it supplies, but it directly benefits the science and art of dentistry by releasing the practitioner from manufacturing toil, and giving time for the acquirement of increased knowledge and skill. Thus, if the time heretofore given to block-making were devoted to the study of dental esthetics, patients would have the benefit of an artistic selection from a far larger variety of porcelain dentures than could otherwise be possibly made. The illustrations of this chapter can but imperfectly convey an idea of the beauty and expression of the originals; they will, however, assist the student in his study of those principles which guide in the selection and arrangement of teeth; they may also serve to awaken practitioners to the extent of the present resources of ceramic dentistry, and to the importance of esthetic culture in order to properly make full use of the same.

The improvements in the Dento-ceramic Art have sprung from a careful inquiry into the essential characteristics which artistically formed porcelain teeth should possess. Among these are (1) *Naturalness;* under which term are included shape, color, and a vital appearance, the last depending upon the precise amount of translucency, the texture of the surface, and the nice blending of the colors of the body and enamel—an appearance which should be maintained as well under artificial as under solar light. Many teeth which will bear inspection reasonably well in daylight have a very unnatural and artificial appearance when exposed in the mouth to a light under which the wearer may be most anxious to excite admiration. (2) *Shape;* which includes a preservation of the distinctive characteristics of each tooth, securing the instant recognition of its position in the dental arch. There must be some defect or inaccuracy of form if, out of the twenty-eight teeth of a set, in unassorted confusion, an experienced eye cannot tell the place of each; for every tooth has its distinctive contour. Not only should each tooth possess the individuality which belongs to it, but it should also indicate the character of its relation to its companions on either side and to its antagonist. The eye trained to observe nature should not be offended by the recognition of any inharmony; should not find a second bicuspid or molar in place of a first, or incisors un-

distinguishable from each other, or an upper tooth in place of its corresponding lower one; nor should it detect in the midst of one style of denture some incisor or canine characteristic of another. Figs. 1176

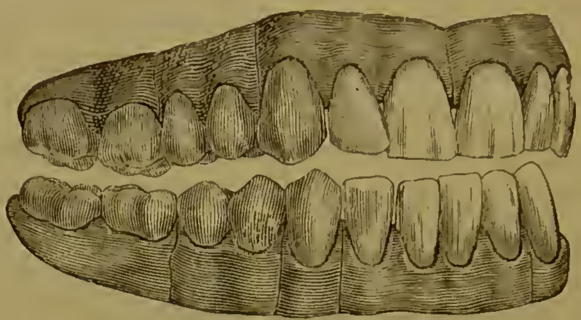


FIG. 1176.

and 1177 exhibit very strikingly the marked peculiarities of each one of the twenty-eight teeth of an artistically designed artificial set; while these and subsequent illustrations demonstrate how possible it is for

FIG. 1177.

modern dentistry to adapt its work to the great varieties of facial expression. Probably every reader has more than once turned at the

sound of a familiar voice, to see a face strangely resembling the looked-for friend. This correspondence between voice and face, often so startling, is only another one of those links between external and internal conformation, which makes the study of esthetic anatomy essential to the success of the dental mechanician.

The great law of correspondence, which enabled Cuvier to build up the entire skeleton from a single bone, makes us associate the idea of intellect with certain forms of forehead, and of character with certain forms of mouth, nose, and chin; it is the same law which permits us to infer from what remains the expression of what is lost. Age, sex, temperament, and complexion, also many physical, mental, and even moral peculiarities, are suggested to the acute observer by certain characteristics of the dental organs. The artist who seeks to restore harmony in the facial expression should be skilled in the observance of these varied manifestations; such skill is demanded alike in the manufacture and in the application of artificial dentures.

In addition to these esthetic qualities porcelain teeth should possess (3) *Strength* adequate to the legitimate use for which they are intended; this strength should come from the quality of their composition, the skillful distribution of bulk to parts most requiring it, and from the due form, position, and proportion of the pins, rather than from any increase in bulk and weight beyond that of the natural organs. They should possess, also, by reason of their conformation (4) *Adaptability* to the various irregularities caused by unequal absorption of the alveolar ridge, so that when judiciously selected they shall require little labor to adapt and antagonize them. Special provision should be made for the results of extreme or very irregular absorption, or for the loss, by disease or otherwise, of parts of the maxillary ridge, so that in such cases the teeth can readily be made to articulate and afford comfort to the wearer, assisting in speech and mastication, and yet not presenting any incongruous appearance.

There are, moreover, special modifications demanded by many other conditions; as, for instance, in cases having a very short articulation, requiring the pins to be set in a recess near the crowns of the teeth and also in countersunk depressions under the base of each tooth, thus bringing the greatest resistance where there is the greatest strain in mastication, as is well shown in Figs. 1179, 1201. In both these blocks the full external size of tooth is given, and its characteristic form and the expression of interdental gum preserved; this could not be done with the usual form of blocks, ground down to suit such cases. In Fig. 1178 we have front blocks for mouths where a shoulder is required to antagonize with the lower front teeth when there are no back teeth remaining. Where early contraction and protrusion of the

upper maxillary arch has caused it to have a sharply curved projection, bringing the closure of the lower teeth much behind the upper ridge

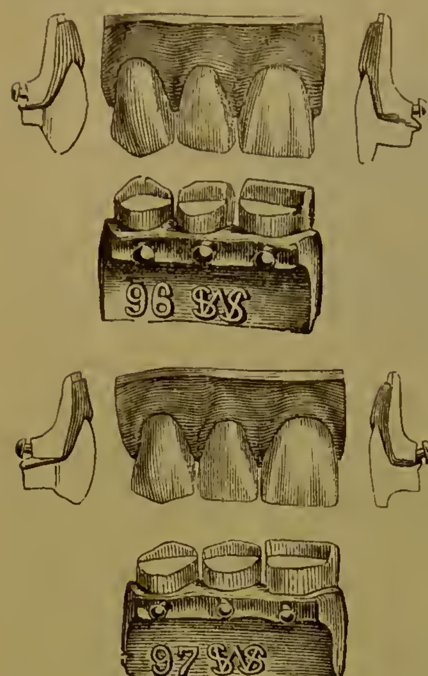


FIG. 1178.

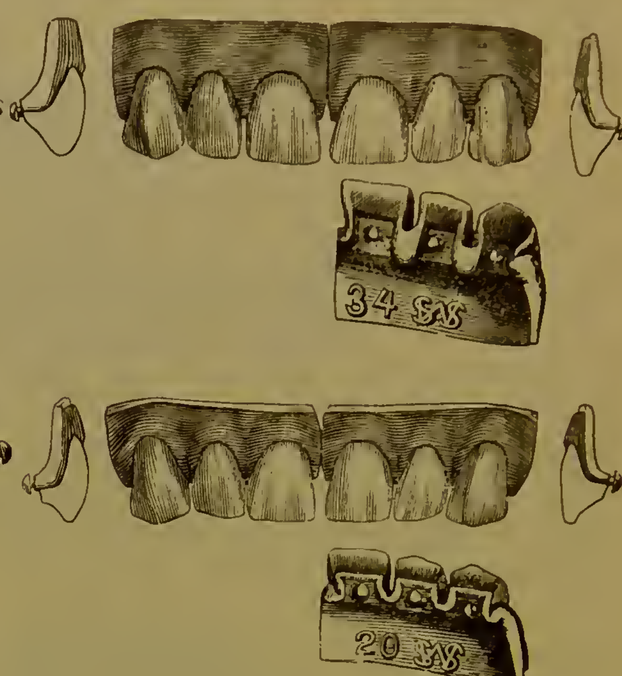


FIG. 1179.

at the central incisors, or where absorption above has left a ridge prominent at its lower edge or margin of the gum, it becomes necessary to give a peculiar twisted form to the front blocks. In Fig. 1180

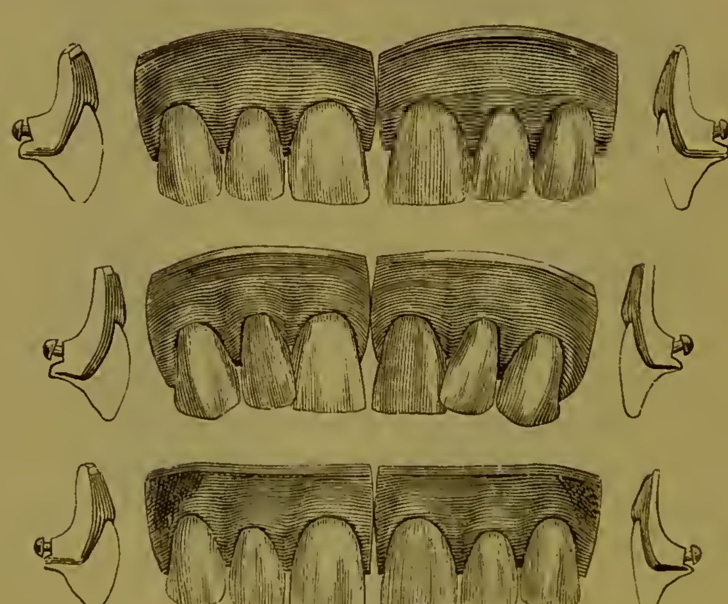


FIG. 1180.

the first two blocks are for a pointed arch, accompanied in the second by a crowded denture, so often seen in such cases. It is impossible to

adapt blocks of ordinary form to such cases without destroying their true expression at one or other of the joints; in fact, much of both gum and tooth is often sacrificed to get correct articulation. The third blocks are shaded with a view to show the fullness of gum at the centrals and its falling back over the canines; this is also shown in the sectional views of the first and third blocks.

For cases in which the lower jaw closes more or less in advance of the upper maxillary ridge, a large gum is often necessary, as in Fig. 1182; but such mouths require a peculiar form of block if the lower jaw has much projection. Where such a prominence of the gum exists, from want of exterior absorption or the previous wearing of a plate, as to require the teeth to be set directly upon the ridge there should be no artificial gum between it and the lip. When the molar block of lower sets extends to where the ramus of the jaw begins to rise, a peculiar plowshare curve of the base is required; such that, while the gum of the second bicuspid lies on the outside of the ridge,

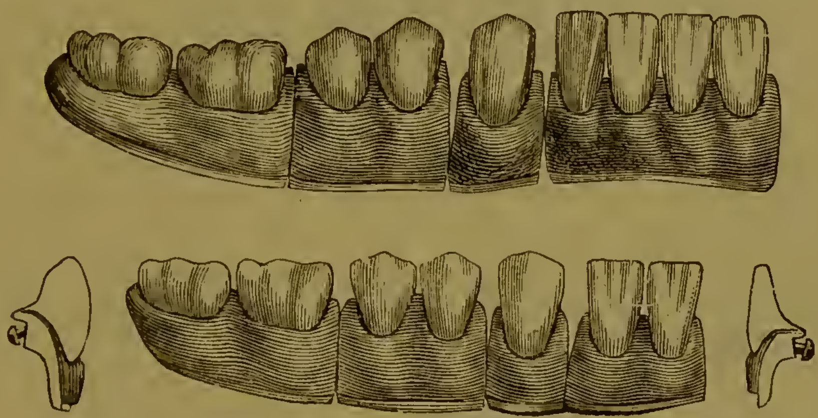


FIG. 1181.

the gum of the second molar may lie partly upon the ridge, so as to give more perfect antagonism with the upper molars. The molar and bicuspid teeth from which Fig. 1181 was drawn are also marked by a characteristic curve of the buccal surfaces, giving not only a very natural appearance, but acting as a guard to the cheek and preventing its being caught between the teeth.

Fig. 1182 illustrates the difference of shape required for a mouth where front absorption permits the artificial gum to overlap the alveolus, and one where fullness of the natural gum requires the block to set directly upon it. In the latter case, if the color of gum is judiciously chosen and the blocks well adapted, the triangles of artificial gum will be scarcely, if at all, distinguishable from the natural; we regard this as an extremely useful form of block. Sectional view of the molar in the upper cut shows the curve necessary to bring its grinding surface directly under the ridge; the views of grinding and

cutting surfaces, together with front views, show how each tooth has a distinctive character; as, for instance, in the bicuspids, so often chosen without regard to the difference in form between the first and second. Again, the curve of the front block shows two of several variations required in the curvature of the arch; in the upper, the sharp turn at the canine gives a squareness across the incisors; in the lower, this turn is at the central and is adapted to a pointed arch. Variations in

FIG. 1182.

curvature of the arch are also shown in Figs. 1177, 1190. Notice also the marked difference in the character of the bicuspids and molars in upper and lower cuts and the totally different expression of the front teeth.

Fig. 1183 shows how the same intermaxillary space may be filled with teeth of a widely different size as well as character. In the first, a very long tooth and short gum; in the second, a very long gum and

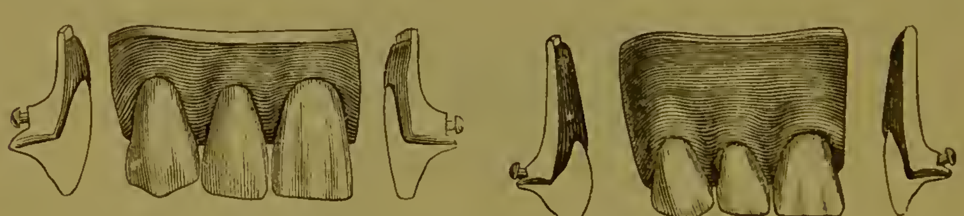


FIG. 1183.

short tooth. But length of teeth is by no means the only difference here; relative size of central and lateral, direction of the axis of lateral and canine, and outline of cutting edge of the block, are three features which equally mark the distinctness of these two styles; these also are points which demand that both long and short teeth shall differ among themselves as widely as these samples differ from each

other. The lateral view of these teeth shows another marked difference in form.

Fig. 1184 gives the characteristic equality of lower incisors, or slightly greater size of the lateral; it also gives some of the diversities in length, width, shape of cutting edge, and form at arch of the gum. Although there is much less difference in the shape of the six lower front teeth than of the six upper, it is a great mistake to suppose that a

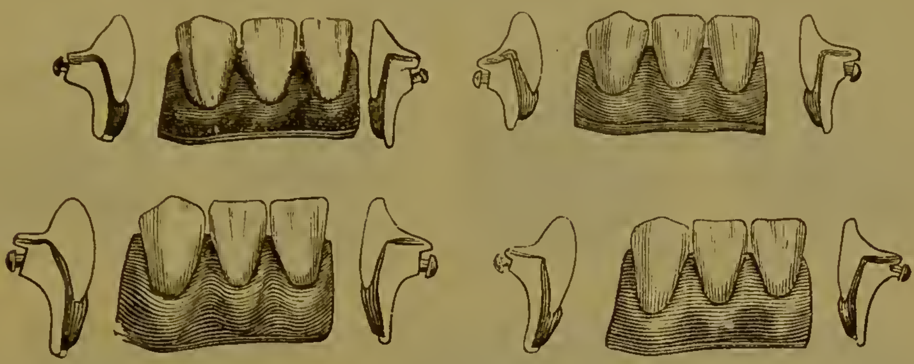


FIG. 1184.

given lower block will answer for any lower case if only long enough. Side views show also a difference in the slant of the teeth, inward or outward, which has an important effect in modifying the expression of the lower arch. There are also differences in curvature of the lower arch as well as of the upper. Fig. 1177 shows the usual upper and lower curves, and Figs. 1182 and 1190 show variations of upper curvature requiring some modifications of the lower, dependent on the

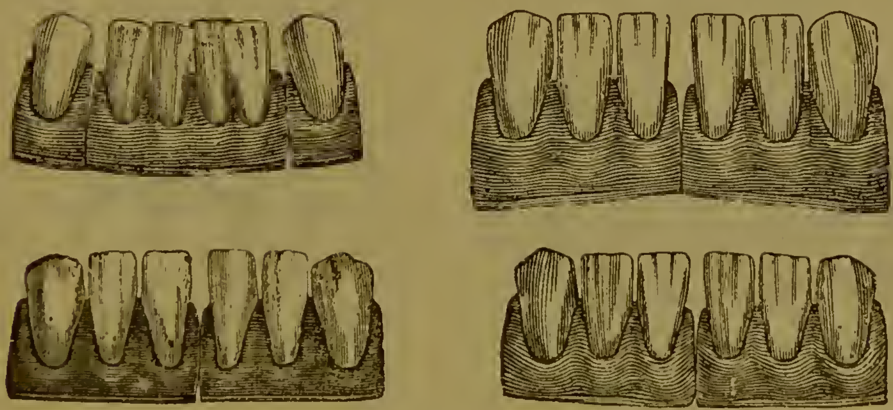


FIG. 1185.

character of the articulation. In Fig. 1185 are four other forms of lower front blocks, the value of which will be at once recognized. The two right-hand sets differ from those of Fig. 1184 mainly in the length and width of teeth. The left lower set is well suited to patients whose natural teeth, for many years before their loss, were marked by exposure of the neck; this appearance may also be increased (sometimes it may

be made) by judicious use of the corundum wheel, but the block here given is invaluable in such cases. The left upper block is an admirable imitation of a very usual arrangement of incisors, resulting from crowded dentition; the drawing gives a very imperfect idea of the great beauty of the original porcelain block. When the facial expression indicates its use, it will have great effect in disarming suspicion of artificiality—a very desirable quality in artificial dentures.

In Fig. 1186 we have very convenient modifications to suit front

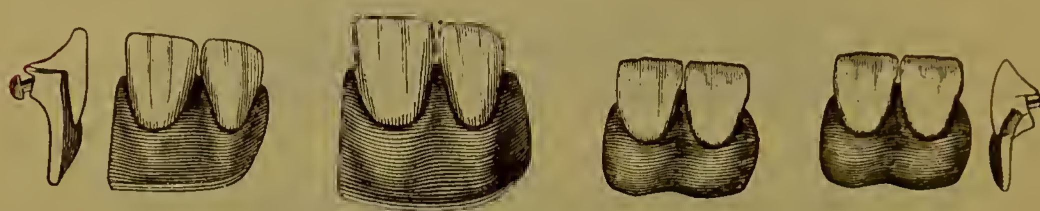


FIG. 1186.

spaces of two or four teeth, the set of four being in two blocks. The peculiarity of these blocks is the lateral finish of the gum; instead of a square joint, for fitting to an adjoining block, they have a rounded edge of gum color that can be adapted to the curves of the absorbed natural gum. There should also be blocks of two, a lateral and central, with gum shaped like the double central, as such spaces are of frequent occurrence. Besides the four forms of teeth here given there

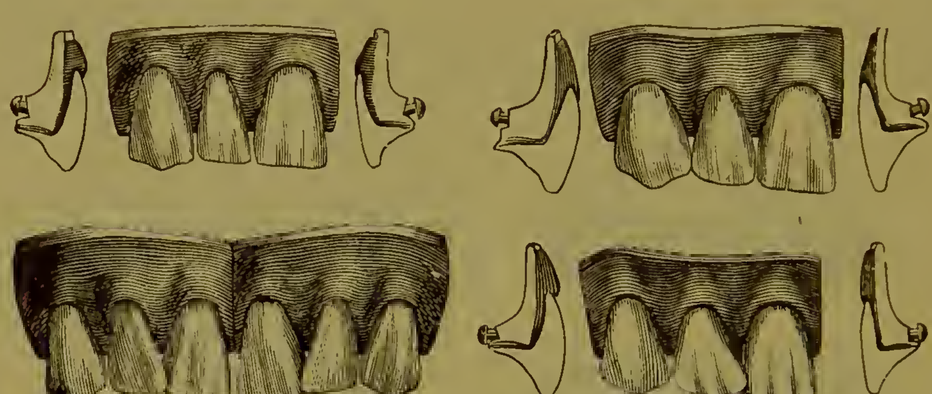


FIG. 1187.

are many other varieties in size and shape of this very useful kind of block.

Figs. 1187, 1188, and 1189 represent a few of the great variety of forms of upper incisors and canines designed to meet the demands of an esthetic discrimination. In Fig. 1187 we have, first, a long, delicate lateral, with sloping but not rounded edge, showing a decided space between it and the cuspid and central; then we find it wider, with corners and edge rounded and filling the space. Lastly, for want of space, the laterals, although long and narrow, overlap the centrals;

this style is generally accompanied with a pointed arch. The fourth block, although with an overlapping incisor, has an entirely different character; it is often found in a rather flattened arch and does not indicate a crowded denture. In these blocks the inclination and shape of the canine as well as the shape of the incisor help to give to each block a distinctness of character which will not permit the use of one in a case demanding either of the others.

The *celare artem* effect of overlapping or twisting laterals, like that of irregular lower incisors, is such as to tempt one to use them whenever admissible. In Fig. 1188 we have some additional varieties of this kind of block. In all these six cases we find differences in the size and character of the lateral, in the extent of its lapping, and in the degree of twist given to it. A careful study of the natural teeth will teach the dentist what character of face is best suited to each of

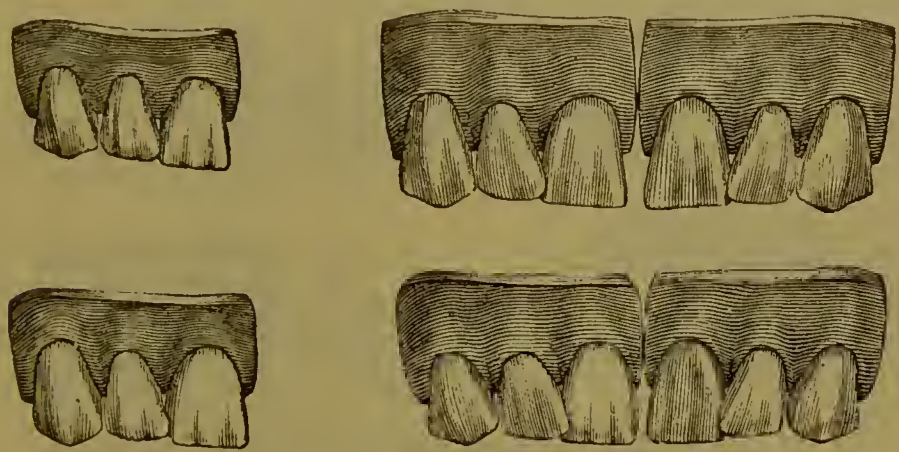


Fig. 1188.

these different forms, and thus he will much increase the extent to which he may properly use this kind of irregularity.

In Fig. 1189 the blocks vary little in size, yet they each have a distinctive character. In the first we have lateral rounded on both corners and its axis vertical; canine, with pointed cusps and edges quite rounded. In the second we have lateral inclined, with median corner pointed, lateral corner quite round; canine with blunt cusp, also axis inclined. In the third, surface of the canine is decidedly furrowed, which, with the indented edge, gives it a marked character; the lateral and central, unlike the previous blocks, have square-cut edges with corners but slightly rounded. In the fourth, the lateral is more nearly equal to the central, and none of the teeth may have any marked peculiarities; this style of block, in its different sizes, suits well in many cases, and is perhaps one of the best for general use by those practitioners who pay no regard, in their selection of teeth, to the indications given by the physical characteristics of the face and head.

The fifth block is one of that class often met with in old age, where, by the action of the lower teeth or other causes, the arch has spread, widening the interdental spaces. The interdental gum is also much shorter than in youth, as is finely shown in the original from which this cut is taken.

In the selection of porcelain blocks not only must the color, size, and form of the teeth be carefully considered, but reference must also be had to the curvature of the arch. For although moderate variations in curvature can be fitted by the same set of blocks, the true expression of a porcelain denture is often lost by the attempt to adapt it to a curve for which it was not designed. In Figs. 1177, 1182, and 1190 we have various curves of the alveolar arch, with corresponding variations in shape of the blocks. Sometimes the canines are made separate with a view to increase the range of application of

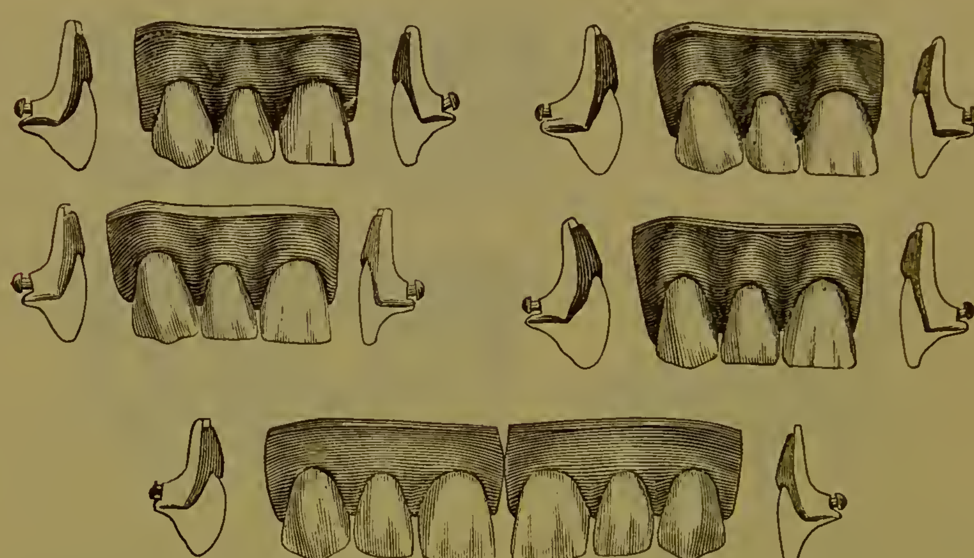


FIG. 1189.

a given set; but a joint on either side is very apt to injure the effect of this important tooth. In the lower jaw it is of less consequence because the gum is less often exposed, and it is frequently desirable to make the four incisors in one block. But in the upper jaw it is much better to have a median joint and another behind the canines.

In Fig. 1190 the reader will notice that the centrals of the first set overlap the laterals, an arrangement of frequent occurrence in prominent and sharply curved arches. It will be observed that in Fig. 1180 the blocks are so shaped that the right or left central overlaps its fellow. Thus we have three varieties of overlapping upper teeth—laterals over centrals, centrals over laterals, central over central—each of which may be used with great effect if applied with discrimi-

nation. In the third set of Fig. 1190, and in a few of the preceding cuts, the gum over the cuspids is very strongly marked. This is a very characteristic feature of some mouths, and when correctly used gives a fine effect; but it would sadly belie the expression in a timid and gentle lady's face. Yet such incongruity is

FIG. 1190.

only one of hundreds constantly occurring, where every sense of esthetic beauty and harmony is violated—teeth of a Russian in the mouth of a Frenchmen, those of a New Englander given to a South Carolinian, or those of a Canadian to a Cuban, the lips of age disclosing the teeth of youth, and no distinction made between

a male and female denture. These esthetic blunders are not confined to the inexperienced tyro, but are perpetrated by many who presume to call themselves skillful mechanicians. When we consider the exten-

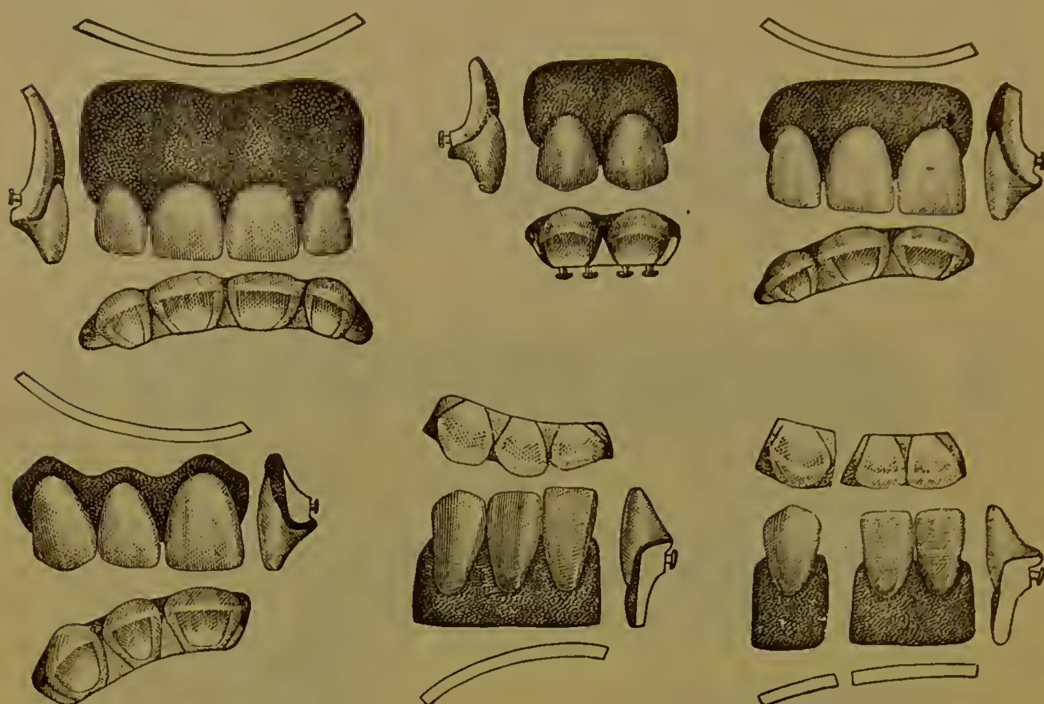


FIG. 1191.

sive assortment of porcelain teeth which ceramic art has placed at the disposal of the practitioner, such malpractice is without excuse.

These are only a few out of the great number of varieties, in size, form, and arrangement, of porcelain teeth; they give to the dentist

FIG. 1192.

FIG. 1193.

FIG. 1194.

a much wider range of selection than some have the ability or inclination to avail themselves of. When to variety of shape we add shades of color, the number of sets that admit of being made, distinguishable at a glance from each other, seems almost infinite. A visit to a first-

class porcelain-tooth manufacturer's rooms will convince any one that incongruity or want of expression in a set of teeth is the fault of him who selects and applies, rather than of him who designs and makes dental porcelain.

Fig. 1191 represents upper and lower gum sections of four, three, and two teeth, one of the upper sections having partial gums.

Fig. 1192 represents an irregular gum section with the lateral out of line.

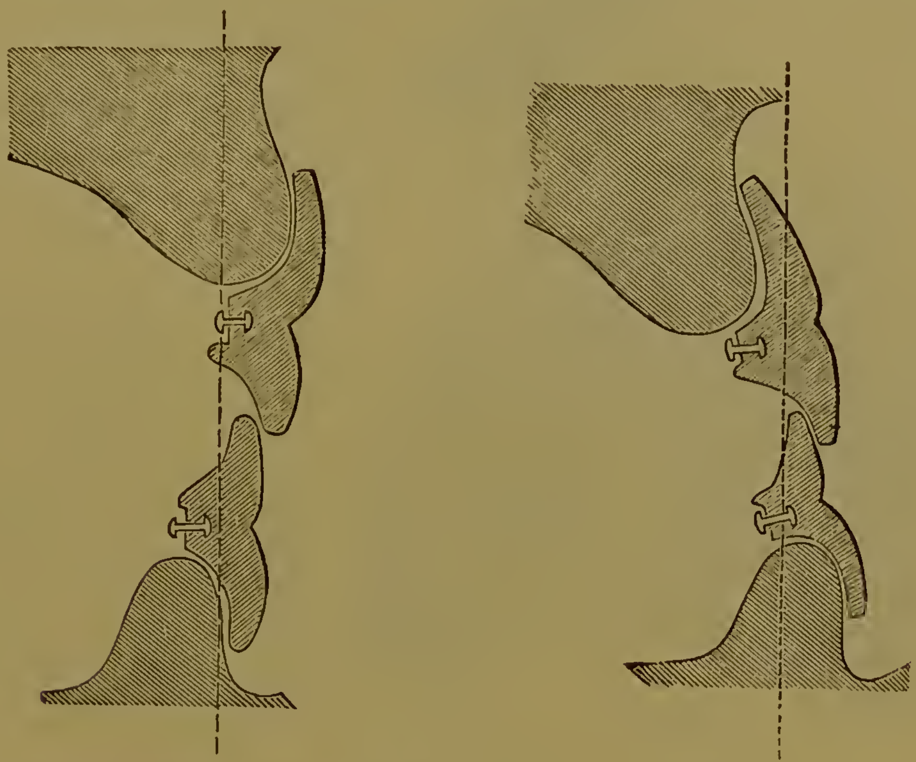


FIG. 1195.

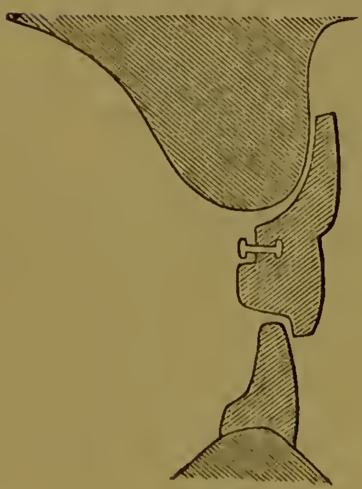


FIG. 1196.

FIG. 1197.

Fig. 1193 represents a gum section with an extra long central incisor.

Fig. 1194 represents a thin gum section.

Fig. 1195 represents gum sections for protruding upper and lower jaws.

Fig. 1196 represents a shouldered gum section.

Fig. 1197 represents a festooned gum section.

Fig. 1198 represents a gum section for a V-shaped protruding upper jaw; the position of the lower teeth is shown by the dotted lines.

It will be perceived that the foregoing illustrations* of the esthetic principles of the dento-ceramic art are taken from one class of teeth, those for vulcanite or metallo-plastic work. We have done so because the art has here had its fullest recent development in consequence of the great demand for this form of block. But dental esthetics is quite independent of the material of the plate, so long as that which is visible in the mouth is porcelain; and dentures which show any substitute for the gum other than this, however useful they may be, cannot rank as specimens of highest art until some material for the plate shall be discovered possessing higher claims to beauty than any yet known.

Fig. 1198.

The foregoing rules will apply to the form and size of plate teeth when these are set directly upon the natural gum; but, except in case of true pivot or plate-pivot teeth, it is impossible to reproduce the precise natural arching of the gum above the tooth without some gum-colored porcelain. We must often be content in such cases with the nearest possible approach to nature. But when the plate is seen on the outside of the arch, the artist's reputation is dependent upon the concealment of the greater part of his work; even here, however, the cutting edge and two-thirds of the tooth permit the display of great varieties of expression. Of

* We are indebted to the kindness of the late Dr. Samuel S. White, and more recently of the S. S. White Dental Manufacturing Company, of Philadelphia, for the admirable illustrations by the aid of which we have been enabled to express our views upon the important subject of Dental Esthetics. No illustrations, however, can convey a true idea of the high artistic excellence of those forms the production of which has placed Dr. White among the greatest benefactors of Dental Art. We take this occasion to acknowledge, also, the liberality and courtesy with which our inquiries for information on the manufacture of dental porcelain were responded to by this gentleman.

plain teeth without gum there are four kinds. 1. Pivot teeth; shaped somewhat like the crowns of the upper incisors and canines, with a hole in the base for insertion of a wooden or metallic pivot. 2. Plate teeth; the oldest known form of porcelain teeth having pins for attachment of a back by which to secure it to the plate. 3. Continuous-gum teeth; resembling natural teeth in having a root, which is more or less serrated, for better retention in the investing porcelain base; they are sometimes made without platina pins; but they are better with pins, so that they may be securely fastened to the platina plate. 4. Plain vulcanite (Fig. 1206); having a small neck, by which they are held in the vulcanite or other material in which they are set. These teeth may be set directly on the gum by grinding off the neck; they may also be used adjacent to natural teeth with exposed neck, by slight alterations of this neck, so as to give to the artificial tooth the same appearance as the natural one.

There are also other forms of gum teeth besides those above represented. Formerly, single gum teeth were extensively used on gold plate, and may still be occasionally required when the supremacy of that old-fashioned material becomes once more recognized in the laboratory. The great facility of adapting blocks or sections in vulcanite work or in vulcanite attachment to swaged plates has led to the almost entire exclusion of this form of tooth except for repairing. A serious objection to single gum teeth is the number of joints; these greatly mar the artistic effect which it is the design of the artificial gum to produce, especially when not kept perfectly clean or when the material of plastic plates is allowed to enter the joints. Figs. 1176 and 1199 are designed to show the importance of correct and accurate grinding in order to display the true character of a set of teeth. When properly done, the joint does not interrupt the continuous surface of the gum more than the lines in the two lower sets of Fig. 1199, nor should it in any case be more visible than the heavier lines of the first set. Neither should the set be so inaptly chosen as to require such grinding of joints and base as to injure its original expression. Figs. 1176 and 1199 should also be carefully studied by the student on account of the varieties of form and relation of teeth presented, each of the four upper sets here displayed having a very distinctly marked character.

Porcelain blocks which are to be attached to a gold plate by soldering do not differ in external appearance from the forms already illustrated; but the shape of inner surface and the form of the pins are different. Fig. 1200 represents such a set of upper blocks in three sections. If made in four sections, the set should be divided between the centrals and between the bicuspids; it may also be in five sections,

the four joints being in front of the cuspids and behind the bicuspids; or it may be divided into six sections, as in Fig. 1176. The line above the pins in Fig. 1200 marks the division between the inner slope of gum next the teeth and the plain surfaces holding the pins; this surface should be as smooth as possible for the perfect adaptation of the gold backing. Blocks may also be made in sets of three or five sections, with the inner surface finished in gum enamel to the plate; in this case the block is held to the plate by pins passing into holes made in its base, one opposite each tooth. The best material for retaining the pins is undoubtedly vulcanite, as described in the previous chapter; the holes should be rough, for its better adhesion.

Fig. 1201 represents the "Countersunk Tooth Crowns," which allow of great facility of adaptation to the maxillary ridge and (it is

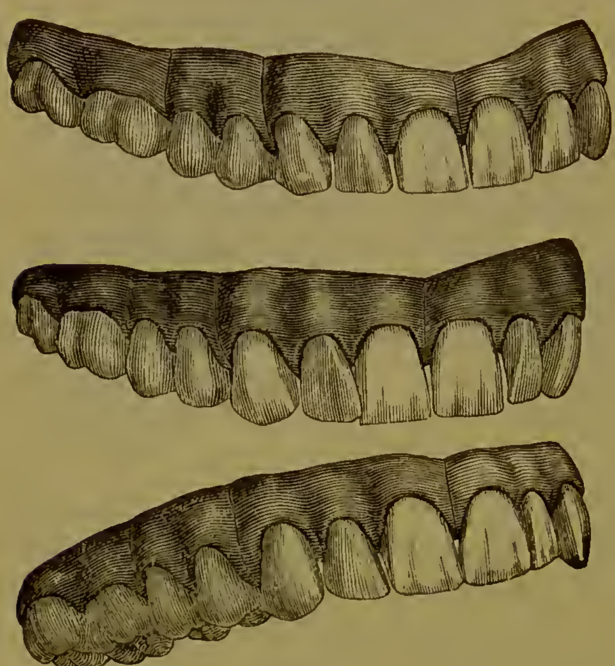


Fig. 1199.

Fig. 1200.

claimed) afford the strongest denture on a plastic base. To insure the best results some precaution is necessary in mounting them, whether on rubber, celluloid, or metal.

For a vulcanite base the case should be flasked as usual, but each countersink should be carefully filled with small pieces of rubber; otherwise the flat rubber sheet will cover the mouths of the countersinks and so shut in the air as to prevent the rubber from reaching the pins and filling the cavities.

When the base is of celluloid the countersinks must be filled in like manner, with pieces of celluloid moistened with spirits of camphor, or preferably with a solution of celluloid, and the case heated to softness before closing the flask.

For a fusible metal base the hot flask should be jarred during the pouring to drive the air out of the countersink.

Fig. 1202 represents perforated bicuspid blocks.

Fig. 1203 represents rubber bicuspid blocks with pins.

Porcelain teeth are now manufactured for vulcanite work with de-

Fig. 1201.

tachable pins which are inserted into dovetailed grooves when the case is being packed.

The dental depots cannot keep on hand an assortment of such blocks, since the demand is too limited to justify the expense of the brass moulds. But in all our principal cities there will be found one or more dental-block carvers, whose experience and constant practice enable them to make any style of blocks that may be de-

sired for special cases. We have elsewhere given our reasons for thinking this a better plan than for the dentist himself to attempt occasional ceramic experiments. Let him prepare an accurate articulating model and adapt a tin-foil plate (to avoid the risk of sending the gold one); then select one or more teeth to guide the carver in the required color and character of the set. If any peculiar form or deviation from the normal arrangement is desired, this should be represented in wax; then pack carefully and send to the block carver. This plan is recommended to those who may desire, for some special

FIG. 1202.

case, a form of blocks not to be had at the depots. Necessarily such blocks are much more expensive than those made by the quantity in brass moulds; but if the dentist values his time, the blocks would cost still more if made by himself.

The true question is, however, not one of cost; if the depot can furnish the form of blocks which the case requires, it is best to get them there, otherwise they must be had elsewhere and at any cost. Dental tradesmen, who sell their wares at a moderate advance on the

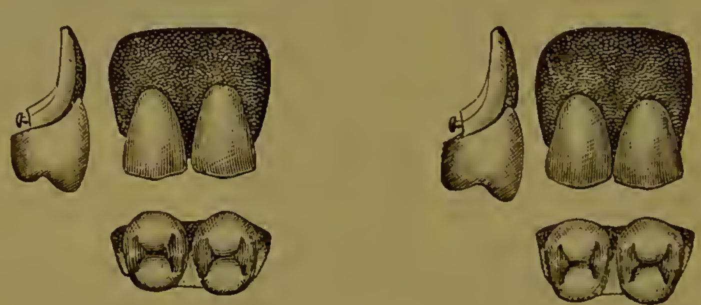


FIG. 1203.

cost of production, may not deem it prudent to deal in such high-priced materials; but the professional dentist, who charges for "services rendered," will never find it necessary to hesitate incurring *any* expense requisite for the perfection of his work. The actual cost of material in single dentures has often exceeded thirty dollars; yet the mechanician who exercises a skill commensurate with this cost never has found, and never will find, difficulty in adding a just compensation for his time and skill. As a rule, patients will

pay best for art when exercised on expensive material, except where, as in painting, the effect produced is wholly irrespective of the cost of the means employed. The true basis of professional fees lies in that which makes one man's work superior to another's; namely, artistic skill exercised upon materials, the quality of which shall not detract from its just appreciation.

As we have briefly described the processes of manufacture of porcelain dentures on a large scale—a work which, of course, no practicing dentist proposes to engage in—it is proper that we should also give a brief description of the processes by which blocks are carved for special cases, although we regard this as equally out of the line of the modern dentist's duties. We occasionally find a genius whose gift shows that ceramic art, not dentistry, is his true profession; but men engaged in ordinary dental practice must, in justice to their patients, make use of the experience of professional block carvers, or they must use those forms offered by the ceramic manufacturer, which are the results of the highest artistic skill which money can command.

SPECIAL BLOCK CARVING.

To make a porcelain dental arch in three sections for a full upper case antagonizing with natural teeth below, make a plaster articulator, as described in the tenth chapter, but having greater thickness to permit guiding holes or grooves, as in Fig. 1204. Open the articulator, increasing the space one-fifth (unless this one-fifth enlargement is to be made by addition of point enamel); place on the plate a wax rim, and trim it to antagonize with the lower teeth, giving the precise external fullness required in the blocks. Mark on wax and front edge of articulator the medial line and the lines of proposed division of blocks; that is, between bicuspids for a four-block piece and behind cuspids for a piece of three blocks; in either case the work is carved in three pieces. It is also well to mark, in fainter lines, the width of each tooth as determined by the size of the lower teeth; this will be some guide in the subsequent enlargement required on account of shrinkage of the porcelain paste. Next make a plaster rim about half an inch thick (Fig. 1027, on page 921, shows the height and thickness), covering the exterior surface of model and wax, making first the front section, extending a half tooth space behind the lines marked for the block joints; then remove this and make the two side sections, extending each a half tooth space in front of these lines. The use of a leaden band and some paper pulp will expedite the making of these plaster sections; they should be trimmed to the exact length required for the crude blocks. Of course, neither in plaster nor porcelain can the front and side sections be applied to the

model or plate at the same time, in consequence of the one-fifth allowance for thickness.

On removing the wax, each plaster section is a matrix to determine the external fullness of the corresponding block, on which is to be carved the shape of teeth and gum. The plate gives exact form to the base of the block ; but when finished it will require grinding, because of the derangement of fit caused by shrinkage. The thickness and interior form of the sections is determined by the eye, and will vary with the style of finish or mode of attachment, being careful, in this direction also, to make the one-fifth allowance for shrinkage. The front block is first made and removed, then each side block separately ;

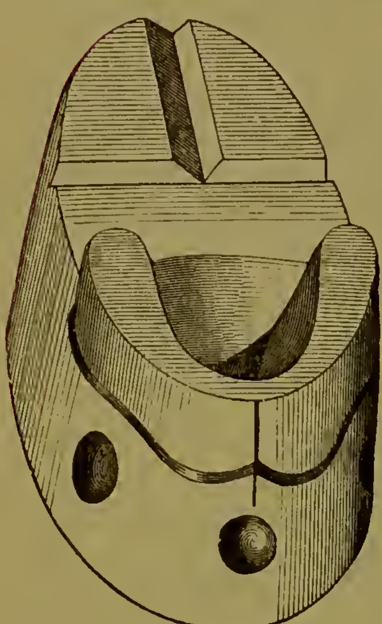


FIG. 1204.

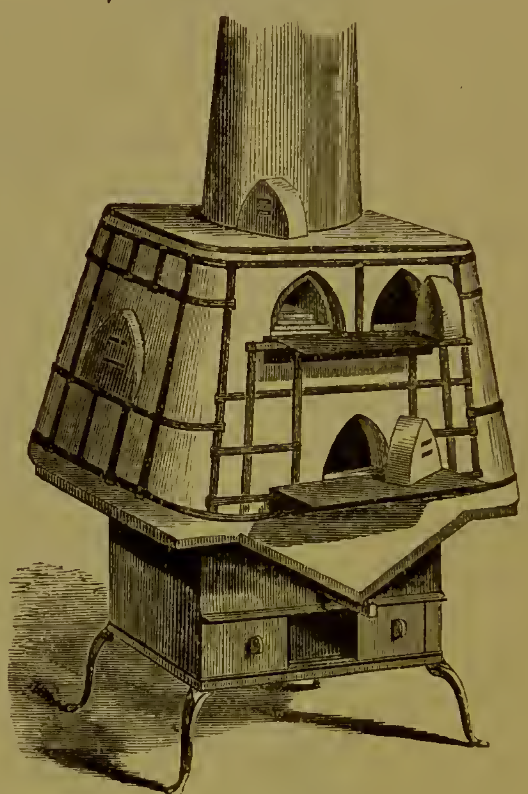


FIG. 1205.

in a double set, both front blocks are made, then both right sections together and left sections together, so as to obtain their proper antagonism ; also, in double sets, the separation of the articulation must be sufficient to allow the one-fifth enlargement in each set.

The porcelain body is prepared as already explained ; it can be compounded by the dentist or purchased from the manufacturer. In mixing the small quantities required for single cases, two points demand special care—purity of the water and absolute exclusion of air from the mass. It must also be remembered that irregular contraction, or warping of blocks in firing, is often caused by unequal compression in pack-

ing the body into the molds and by unequal absorption of its moisture by the porous plaster rim or other means used to dry it. Again, it should be remembered that in removing the rim, in carving, and in all other operations on the crude paste the excess of feldspar gives it a tenderness very different from the tough plasticity of a kaolin mass. The putty-like body is to be carefully worked into the well-oiled mold, compressed with the fingers, trimmed into outline shape, and then removed, first marking upon it the lines of the articulator to guide in the carving. The block may be partly or entirely carved while on the articulator; but the delicate movements of the very delicately-shaped carving tools are, in the opinion of some, best exercised upon the free block.

For carving no directions can be given beyond what has heretofore been said on the necessity of a close observance and exact copying of nature. The artist requires no written directions, and paper instructions never yet made an artist out of a bungler; in fact, the heaven-born genius of art cannot be created by teaching, however it may be trained and directed. Many have wasted years in porcelain block carving only to produce results surpassed by the least artistic forms offered in the depots; while, on the other hand, some dental Palissy will work out a marvel of beauty that no purchased blocks can equal. But before one imagines himself a Bernard Palissy let him read the history of that wonderful struggle of genius, then ask how far the routine duties of a dental office will permit an exclusiveness of devotion which ceramic art rigorously exacts as a condition of success.

When carved, the blocks are thoroughly dried, then placed on coarse silex upon a fire-clay slab, and set into the muffle of the furnace (Fig. 1205). Here they are biscuited (or cruced), that is, raised to a red heat sufficient to give some hardness, but not to vitrify or even to cause incipient fusion. They are then slowly cooled and holes drilled for the pins, or else holes drilled into the base of the blocks, as may be preferred; the pins are fastened in place by a little "body-slip," carefully worked in with the knife point. Slight defects of carving may now be corrected; the enamels are then applied with a camel's-hair brush. They must be reduced to the consistence of cream, and require much skill and judgment in their application, so that the point enamel shall blend properly with the body enamel; also the gum enamel must preserve its distinctness of outline and, by its varying thickness, give those alternations of shade observable in the natural gum. It should here be remarked that some carvers make no allowance in the body for shrinkage in length of the tooth, but compensate by the addition of point enamel. The crowns of bicuspids and molars are usually enameled; also part of the inner surface of the blocks, and in some

blocks the gum enamel extends to the base. When platina pins are inserted, the part of the block to be covered by the backing is not enameled. It is scarcely necessary to remark that a large assortment of body, point, and gum enamels is required; also that these must, with great care, be kept separate, with their respective test pieces attached, for except by the pinkish color of gum enamel they cannot be distinguished when in form of powder, paste, or cream.

The blocks are now well dried and are ready for the furnace, Fig. 1205. (For other forms of furnaces see article on "Continuous Artificial Gum.") Success thus far is dependent upon: 1. Thorough mixing of the body and its careful packing; 2. Skillful carving, so as not only to give the required expression, but also to know what allowances to make at each point for shrinkage and for the subsequent application of the enamels; 3. Selection of enamels and their skillful blending and shaping; 4. The giving of such form, in adjustment of the relative length and thickness of each block and apportionment of material, as shall prevent warping in the furnace. These points, however, may have been perfectly attended to; yet all will have been done in vain, unless the operator has a thorough practical knowledge of the management of the furnace. It is this which makes the ceramic experiments of the practicing dentist so often a failure; for fail he certainly will unless he knows the exact heat at which the differing fusibilities of his body and various enamels will, by their combined effect, develop the properties aimed at in their combination. Some are governed in this by test pieces; the experienced workman, guided by constant practice in a way that he cannot explain, prefers the indications offered by looking at the piece itself. If not sufficiently baked, the body will be porous; also, neither this nor the enamels will have their true life-like character. If overdone, there is an offensive, glassy, and transparent condition, equally fatal to the natural appearance; also, there is too much shrinkage and greater danger of warping. Both errors impair the full strength of the porcelain, in which the ingredients are so combined as to develop greatest strength at a certain temperature.

Furnace temperature is measured by instruments called Pyrometers. The limit of mercurial registration of temperature is 600° Fahrenheit. Daniell's pyrometer registers by the expansion of a platina rod in a plumbago case and is the most accurate. Wedgwood's pyrometer registers by the rate of permanent contraction of kaolin under intense heat. A clay wedge fitting the upper part of a tapering groove will, after exposure to furnace heat, slip further into the groove; supposing the rate of contraction uniform, this distance will be a measure of the heat after establishing its exact relation to the 600° point of Fahren-

heit. But the contraction of any two pieces is not the same unless their composition is identical; also, the relation to the mercurial scale is not easy to determine. Wedgwood's zero was 1076° Fahrenheit, and he estimated one degree of his pyrometer equal to 130°; on which basis of calculation the highest heat of the porcelain furnace (130° *to* 160° Wedgwood) would range from 19,000° *to* 22,000° Fahrenheit. Others estimate his degree at 62.5° Fahrenheit, reducing the registration from 9500° *to* 11,000° Fahrenheit. Taking the fusion point of gold at 2000°, and of pure iron at 3000°, we thus have some idea of the infusibility of platinum and the extreme heat of ceramic furnaces. But it is evident that the correct regulation of this heat must be the result of experience rather than of written direction; also, that the furnace practice of different persons cannot be accurately compared.

The muffle protects against the gases of the fire. Charcoal, coke, or anthracite are used as fuels, according to the location of the operator; the last is preferable when it can be procured, because it gives the steadiest heat; charcoal requires practice to maintain a uniform heat; coke is used in all the bituminous coal regions. With either of these, after sufficient experience, a furnace may be kept regularly at the required heat for a length of time sufficient to fire the porcelain blocks. They must be thoroughly dried on the furnace-shelf before going into the muffle; the mouth of the muffle should be well luted, and the stopper withdrawn only to examine the work. The more slowly blocks are cooled, the more perfectly are they annealed, and hence less liable to crack from sudden changes of temperature, as in soldering.

Not to interrupt the order of operations, we have deferred the description of a very ingenious method of carving devised by Dr. William Calvert. Instead of the wax rim before mentioned Dr. Calvert provided an assortment of teeth having all the varieties of form and size required in practice, but one-fifth larger than the given case. These are arranged in a wax gum and the plaster mold then taken. Thus, in Fig. 1206, teeth of the first size set in wax will give, when diminished by the furnace, teeth of the second size; so in Fig. 1184, each of the two lower sizes in wax will give in the finished block the size above it. Dr. Calvert's method has three recommendations: 1. Like continuous-gum work, it limits the necessity of esthetic skill (which so few possess in high degree) to the shaping of the gum, the judicious selection of teeth, and their proper arrangement, leaving the details of form to the genius of the manufacturer's artist. 2. It permits the application of enamels, or rather the addition of body to enamels, without the necessity of crucing, which some

regard as injurious to the tooth. 3. By selecting a variety of styles of model teeth, and by varying the relative adjustment of them in the wax, that tendency to uniformity of style is obviated which characterizes almost every block-carver's work.

Dr. Calvert's process differs mainly from the foregoing in the following details: For a four-block piece the teeth are set in wax shaped in exact imitation of the natural gum, omitting the second bicuspid, in place of which a half-tooth space is left between first bicuspid and molar, the wax gum being carried around continuously. The plaster mold of the eight front teeth is then taken, a thin septum of foil being placed opposite the mesial line, so that it may be easily broken there in the act of removal, the plaster coming slightly over the inside so as to give with certainty the shape of the cutting edges. Upon removing the front mold, and before making the lateral molds, where as yet the wax holds only two molars, it is necessary to detach the bicuspid of the front block and put it adjacent to the molar; this gives the arch its full complement of bicuspids. This must be done very neatly, so as not

FIG. 1206.

to disturb the continuity of the wax gum, otherwise the effect of the porcelain blocks at their joints will be injured. Dr. Calvert prefers using cuspids for insertion in the wax instead of bicuspids, since their external expression is similar and their form more convenient, especially in the change just described. By similarity of form we do not mean that in any mouth the canines and bicuspids are alike externally; but out of a collection of canines, after choosing the cuspids themselves, others may be selected harmonizing with them as first and as second bicuspids. Besides overlapping the blocks at the bicuspids, to compensate shrinkage, a slight extension of each block beyond the last tooth should be made to allow for accurate grinding. If holes are made in the base, instead of platina pins in the back, it will be best to make a continuous front block of six teeth, in which case the half-tooth space above named comes behind the cuspid.

Since the carved wax of the contained teeth makes carving of the porcelain paste unnecessary, the plaster molds are varnished, oiled, and treated as are the brass molds in wholesale manufacture. The stiff

paste of point enamel is placed with a delicate spatula into each tooth matrix, thickest at the point and disappearing at the neck. The tooth enamel paste is then applied, with thickness reversed; gum enamel might also be added in the same way, but it is usually applied afterward with the brush, as this permits delicacy and uniformity of coating or easier modification of its thickness. A layer of soft body paste is now laid over the enamels, the mold is placed on the articulator, and the thickness of the block is built out and shaped in the usual way, compressing it firmly, and removing the surplus moisture with bibulous paper or the blowpipe flame. The block is next carefully removed, and while resting in its matrix the platina pins are inserted or holes drilled in the base, or dovetails cut, as may be preferred, and the whole inner surface examined and trimmed. If the inside of the block is to be finished in gum, the enamel should now be applied; then remove the block from the matrix and apply the outside gum enamel and trim between the teeth, where the thin edges of the plaster matrix are apt to be defective; the block is then ready to be dried and placed in the furnace, where it is fired at a single heat without previous biscuiting. The side blocks are made in precisely the same manner.

ENTIRE PORCELAIN PLATES.

In addition to what has already been said upon this subject, it is only necessary here to consider some of the preceding properties and manipulations of the porcelain material in its use as a plate and without any metallic support. Neither in itself, nor by known combination with any substances, can a thin porcelain plate be otherwise than frail. The fusible porcelain of the "continuous-gum work" is supported by the platina plate and the continuously soldered platina backings. Such porcelain, without metallic support, would be very frail. In endeavoring to give strength by decreasing the flux and increasing the refractory ingredients, we are at once met by the difficulty of shrinkage. Thus we encounter two horns of a dilemma—a very fusible porcelain with less contraction but great tenderness, a more refractory porcelain with greater strength but the usual one-fifth contraction, which necessarily destroys the fit of the plate if made over the unchanged model.

Dr. Allen frankly acknowledges the weakness of his very beautiful porcelain by giving it a metallic support. The dentist knows just what he is using here (see Continuous Gum), and can exercise his judgment upon the suitability of the work to any case in hand. The few dentists who make entire porcelain plates are more reserved in communicating their knowledge. Such unprofessional reserve is damaging to dentistry as a science; it would injure it also as an art if entire porcelain dentures had a strength equal to their beauty. It

is claimed by some makers of these plates that their formulas give a porcelain which is very strong, yet has a very slight shrinkage. But until such formulas are made known to the profession and an opportunity given to test them, the general prejudice against the entire porcelain base must continue to be well founded. To those desirous of experimenting in this direction we might suggest the use of silicate of magnesia and lime (asbestos) and coarsely pulverized porcelain fragments, as perhaps lessening the shrinkage of the mass.

By some the ordinary dental porcelain paste is used, making provision for shrinkage by enlargement of the model. One method of enlargement is as follows: With a fine saw divide the plaster model by a cut through the median line and another on each side; separate these four sections one-eighth inch and fill the joints with plaster, first saturating them with water; then cut the model twice at right angles to the first lines and fill with plaster as before. If the back of model is perfectly level and the work is very carefully done we shall have a tolerably accurate enlargement of about one-fifth. Make a plaster matrix over this, and into it pour a furnace model composed of three or four parts asbestos or sand to one of plaster. On this mold and carve and bake the plate and teeth; else transfer the plate to a pile of coarse silex so arranged as to give it as much support as possible during the firing.

Teeth and plate are sometimes carved out of the same mass on the enlarged model; or blocks may be made as already described, then transferred and united to a porcelain plate on this model. Sometimes the teeth from the depots are arranged in the porcelain paste and gum enamel applied around the teeth and over the plate. Unlike continuous-gum work, the teeth are not attached to any unyielding plate; hence they are liable to change position by the contraction of the plate during firing.

We cannot more appropriately close this chapter on dental porcelain than by quoting some remarks of the great English ceramic manufacturer, Josiah Wedgwood, applicable to the art which he did so much to elevate. They have a significance beyond ceramic art, and convey, in this lesson of the past, a warning to those who may, perhaps unconsciously, be dishonoring the profession of their choice.

"All works of taste must bear a price in proportion to the skill, taste, time, expense, and risk attending the invention and manufacture. Those things called dear are, when justly estimated, the cheapest; they are attended with much less profit to the artist than those which everybody calls cheap. Beautiful forms and composi-

tions are not made by chance, nor can they ever, in any material, be made at small expense. A competition for cheapness and not for excellence of workmanship is the most frequent and certain cause of the rapid decay and entire destruction of arts and manufactures."

ESOPHAGOTOMY.

As the accident of swallowing artificial dentures has occurred more or less frequently, and has in some cases resulted in death, the following case will describe the operation of removal where all efforts of a more simple nature failed to give relief:*—

"On Sunday, November 14, 1886, George K. (white), aged thirty-two years, while at dinner had the misfortune to partially swallow his set of artificial teeth, consisting of a rather narrow vulcanite plate for the upper jaw, to which were attached three incisors, one lateral incisor having been lost from the plate. The denture was arrested in its passage downward, producing intense pain and partially obstructing respiration, while deglutition, even of liquids, was rendered impossible. A physician was summoned, who detected the plate in the upper portion of the esophagus; but all efforts to remove it or force it into the stomach were futile. Sufficient opium to relieve the pain having been administered, on the following day (Monday) he was brought by his physician to the infirmary of the University of Maryland and placed under the care of Dr. L. McLane Tiffany, professor of surgery. On the same afternoon, the patient having been etherized, careful attempts to remove the plate were made, but it was so firmly impacted in the upper portion of the esophagus that all effort for its removal failed. On Tuesday, in the presence of the medical and dental classes, the patient was again etherized and efforts made to remove the plate through the mouth, but without success.

"The patient lying on his back, with his face turned to the right, so as to render the tissues of the left side of the neck tense, Prof. Tiffany made an incision about four inches in length through the integument over the depression between the trachea and the sterno-mastoid muscle. The anterior jugular vein was cut and ligated, and the incision extended from opposite the upper border of the thyroid cartilage nearly as low as the sterno-clavicular articulation. The platysma myoides muscle and the cervical fascia were then divided. The edges of the wound being held apart by retractors, the omohyoid muscle was drawn outward, and the sterno-hyoid and the sterno-thyroid muscles

* This operation was reported for the *Dental Cosmos* and *Am. Journal of Dental Science* by Prof. F. J. S. Gorgas.

inward. The carotid sheath, with the contained vessels, was exposed and carefully drawn outward, while the thyroid gland was separated as far as necessary and drawn inward. The larynx and trachea were drawn somewhat forward, and the finger passed behind, where the foreign body could be distinctly felt through the esophageal wall.

"Care being taken to avoid the recurrent laryngeal nerve, an incision large enough to admit the finger was made into the esophagus, through which the exact position of the set of teeth was ascertained. Forceps were then introduced and the plate removed intact. The wound, after being thoroughly cleansed, was dressed with antiseptic gauze and absorbent cotton, no sutures being employed. On the following Thursday the patient was walking about his room, having a normal temperature and pulse. He was fed by means of a stomach-tube for six days, after which he was able to swallow liquid food with little or no pain, and the external wound had nearly closed."

CHAPTER XVII.

DEFECTS OF THE PALATINE ORGANS.

One of the most distressing deformities to which the human frame is liable is found in that defective condition of the palatine organs which is known to surgeons by the name of Cleft Palate. The unfortunate sufferer is compelled, in a great measure, to be an alien among his fellow creatures; an object of compassion to the considerate, he is often made painfully conscious of notice by the heartless crowd; and were he gifted with the power and eloquence of a Demosthenes or with the garrulousness of a Cleon he could make little more use of his endowments than a mute. Fortunately this painful defect is no longer to be reckoned as one of the *opprobria medicorum;* for both surgical and mechanical means are now at hand by which the imperfection may at least be remedied, and often cured.

Defects of the palatine organs may be divided into two classes, viz.: Accidental and Congenital. The first includes all loss of substance in either hard or soft palates, whether occasioned by disease or otherwise. Such defects are not uniform in locality nor in extent, consisting sometimes of simple perforations and at others involving the destruction of the velum, a considerable portion of the os palati, the vomer and turbinated bones, and the loss of a greater or less number of the teeth. The second class includes all malformations, from the simple bifurcation of

the uvula to an opening through the velum, palatine, and maxillary bones, and a fissure of the upper lip; thus uniting the nasal passages with the oral cavity throughout their entire extent.

These malformations are quite similar in character, but not uniform in extent. They may be said to begin with the uvula, and in the uvula and velum always *occupy the median line;* but as the defect progresses anteriorly, it may deflect to one side or the other of the vomer and, following the nasal passage, divide the lip, leaving the vomer articulated with the palatine bone upon one side; while in other cases the deformity seems to follow the median line, and thus involves both nasal passages, terminating in a double fissure of the lip.

Congenital defects of the palate are usually accompanied by more or less deformity of the sides of the alveolar arch and of the teeth. Sometimes the sides of the alveolar ridge are forced too far apart, and at other times they are too near each other; while the teeth are either too large or too small, and are generally of a soft texture with imperfectly developed roots.

Want of coaptation, resulting from defective formation in the palatine plates of the maxillary and palate bone, is the cause of congenital deficiencies of the parts in question. In the human embryo of about the third week the development of the *face* is clearly in progress. Five tubercles bud out from the front of the cephalic mass, of which the middle one (which is double) is directed vertically downward, and bears the appellation *incisive tubercle* because the intermaxillary bones, destined to hold the superior incisor teeth exclusively, are developed in it. On either side is the tubercle, or rudiment, of an upper maxillary bone, which is separated from its fellow by a wide interval, and from the neighboring incisive process by a fissure. The fourth and fifth tubercles, also separated in front, form by their subsequent union in the median line the inferior maxillary bone. At the same period the palate begins to be formed by the approach toward the median line of two horizontal plates, or processes, springing from the maxillary process on either side. (See Development of Bones of Head and Face.)

If now development proceed regularly and normally, the palate processes of the superior maxilla meet in the median line and unite with the blended intermaxillary tubercles, while the vomer grows downward to meet the palate processes in their line of union. The upper jaw, after the accomplishment of these changes, is complete, and the formation of the lip and primary dental groove follows in due course. But it sometimes happens that the superior maxillary and intermaxillary processes fail to unite with each other; whence we have the malformation known as *harelip*, or the palate plates are arrested in

their growth, and permanent *fissure of the palate* is the result. Consequently, the fissure of single harelip is never exactly in the median line, but on the edge of the intermaxillary bone; whereas, in double harelip, a fissure exists on each side of this bone, in which the four incisor teeth are planted.

Fissure of the hard palate is usually a little lateral, and not median, as it results from a deficiency of one or other of the palate plates of the upper maxillary bone, and it is frequently associated with harelip and fissure of the upper jaw.

FIG. 1207.

The tubercles, or formative processes of the lower jaw, advance and meet in the median line, while the upper maxillary processes are still separate. In man they are consolidated into a single piece; but they remain permanently divided in many of the lower animals by a median suture.

The principal effects resulting from an absence of a portion of the palatine organs are, an impairment of the functions of mastication, deglutition, and speech. Distinct utterance, is sometimes wholly destroyed, and mastication and deglutition are often so much embarrassed as to be performed only with great difficulty.

These effects are always in proportion to the extent of the separation or deficiency of the parts. The simple act of triturating the food may not be materially impaired by the absence of a portion—however extensive—of the palatine organs, unless the natural relations of the teeth of the upper and lower jaws are changed; still the process is more or less interfered with, as substances taken into the mouth cannot be so readily managed as when the parts are in their natural state. They are liable to escape from the control of the tongue and pass into the cavity of the nose.

In cases of congenital defects of the palate and velum it is difficult to conceive how infants manage to obtain from the breast of the mother or nurse the food necessary for their subsistence; yet, even when the anterior part of the alveolar border and part of the upper lip are wanting, the suggestions of natural instinct enable them, by a peculiar management of tongue and lip, to do it. The expedient resorted to for effecting this process is curious. The nipple, instead of being seized between the tongue, upper lip, and gum, is taken between its lower surface and the under lip and gum, and in this way it manages to extract the nourishment necessary for subsistence and growth. The tongue is thus made to close the opening in the palate and perform the office of an obturator. By contracting the lip and

depressing the tongue the milk is drawn from the breast of the mother or nurse. At this young and tender age the child is not conscious of the imperfection of its palate; and it is not until the period arrives when it should begin to make its wants known by words that it feels the importance of the function of speech, and begins to realize the misfortune with which it is afflicted.

As the child arrives at this period, the mechanism of sucking is perfected and is ultimately applied to the mastication of solid aliments. The food, when chewed, is conveyed between the tongue and movable floor (which serves for a *point d'appui*), and it is brought back between the teeth. Thus it is that the complicated operation of mastication and deglutition is performed without the alimentary morsel getting into the nose, or, if this does sometimes happen, it is the result of accident. But in cases of accidental lesion of the palate the individual has not the advantage of this training of the parts during early infancy. Those who are afflicted with accidental lesions, no matter what may be their position and extent, having acquired the habit of eating by placing the aliment upon, and not under, the tongue, can take no nourishment without a part of it getting into the nose. When to this inconvenience is added a change in the natural relation of the teeth of the two jaws, mastication is rendered still more difficult and embarrassing. When this is the case the tubercles of the teeth of one jaw, instead of being received into the depressions of those of the other, strike upon their protuberances, and cannot be made to triturate the food in as thorough and perfect a manner as is required for healthy and easy digestion. Thus not only is the process of mastication rendered imperfect, but it is also more tedious.

The process of deglutition itself, so long as the velum and uvula are perfect, is not materially affected by a simple perforation of the vault of the palate, although much difficulty may be experienced in conveying alimentary and fluid substances to the fauces and pharynx. But when this curtain is cleft, or is partially or wholly wanting, deglutition is rendered very difficult, for by the contraction of the muscles of the pharynx part of the food is forced up into the nose. The reason of this will appear obvious when we take into consideration the form and function of this movable appendage. When its muscles are relaxed it forms a slightly concave curtain ; but in the act of deglutition the muscles contract, raise the velum, and close the opening from the pharynx into the posterior nares. By this valvular arrangement alimentary substances and fluids are prevented from escaping into the nose. It matters not, therefore, whether the imperfection of the velum palati be the result of accident or disease ; its effects upon deglutition

are the same. In proportion as the lesion or deficiency is great will this operation be rendered difficult and embarrassing. There are cases where, in consequence of an imperfection of the palate, the patient can swallow no fluids without a part being returned by the nose. To obviate this inconvenience the head is thrown sufficiently far back to precipitate them into the esophagus. This is an expedient to which many thus affected have been compelled to resort.

Imperfection of speech always results from an opening in the palate; it gives the voice a nasal twang and renders the formation of some sounds impossible. The loss of the teeth, to a less extent, is productive of the same effect. To comprehend fully the manner in which a lesion of the palate may affect the utterance of speech, it will be necessary to understand the agency which the several parts of the mouth have in the formation of articulate sounds. Speech consists in the sounds produced by the organs of the glottis modified by the organs of the mouth. The modulation of the voice, that is, the raising or lowering of its pitch, is accomplished by the vocal cords of the glottis; but the articulation of the consonants requires the co-operation of all the movable and fixed parts of the mouth and pharynx, palate, tongue, lips, teeth, and palatine arch. Hence if any of these be defective or wanting, the power of forming some of these sounds is wholly lost, of others very much impaired; hence, also, the ability to sing is much less interfered with than the power of distinct speech. The tongue has a remarkable power of adapting itself to the loss of teeth and of some other parts, so as measurably to correct the effect on speech; but the effect of the loss of the hard or soft palate upon the voice cannot be remedied in any such way.

In both cases (accidental and congenital) the faculty of distinct articulate speech is seriously impaired by defects of any extent. In ordinary cases of congenital deformity in an adult, deglutition is not materially interfered with. The patient, having never known any other method of swallowing, is not conscious of any difficulty. Accidental lesions, however, coming generally in adult life, produce, in this respect, very great inconvenience. The remedy for these evils must be the closing of the abnormal passage by some means which will restore to the deformed organs their functions. In perforations of the hard palate, unless of extraordinary extent, the method is very simple. In the loss of the soft palate by disease the remedy is more difficult, and in extensive congenital deformity still more complicated means must be resorted to.

STAPHYLORRHAPHY.

The operation which is resorted to for closure of a cleft in the soft palate is known by the name of Staphylorrhaphy, a word of Greek

derivation, signifying suture of the uvula. It is an operation which has been successful in many instances, although there are numerous cases which will derive far more benefit from mechanism than from the surgeon's aid or a surgical velum.

To obtain success in staphylorrhaphy, the first care must be to gain a practical acquaintance with the position and relation of the muscles connected with the palate and fauces; and this can be accomplished best by laying open the pharynx from behind, for thus the posterior surface of the soft palate is at once exposed to view. This structure is wholly composed of muscular tissue covered with a layer of mucous membrane continuous with that lining the hard palate.

The muscles with which we have chiefly to do are: the palato-glossi and the palato-pharyngei, forming the anterior and the posterior pillars of the soft palate respectively; the levatores palati, the tensores palati, and the azygos uvulæ. The origin, insertion and actions of these muscles are given on page 63.

The actions of these muscles show what an important part they must bear in regard to the operation of staphylorrhaphy; and when this is considered in detail, it will be seen why but little success was met with until means were found to render muscular action of the parts impossible.

The deficiency of the palate varies considerably, from a mere division of the uvula to a gap which constitutes a hopeless deformity. When this abnormal state is limited to the soft palate, the cleft is always of a triangular shape, the apex being above and the base below; but when the soft and hard structures are involved, it is of a more or less quadrilateral shape.

We shall here only consider those cases which are congenital in their origin, merely alluding to the distinction between this class of deformity and that kind which may be said to be acquired, or is accidental. In congenital cleft the fissure is generally confined to the median line of the palate, because the two halves have not united at that part at the usual period. In acquired or accidental deformity lesions are met with in all parts of the palate, to the right or left of the median line, and are usually the result of syphilitic ulceration, or have some traumatic origin.

Congenital clefts may be thus classed: Firstly, a small, triangular-shaped fissure, extending through the uvula and the posterior portion of the velum palati, the other portion of the palate being quite intact and sound. Secondly, the whole of the soft palate is involved. Thirdly, the soft palate and a portion of the palate bone is deficient. Fourthly, the cleft may be associated with abnormality in the alveolar process of the palate bone, and even with harelip. Fifthly, openings

occur in the hard palate, the soft palate being unaffected. These separations may be very narrow, not exceeding a few lines in width, or the gap may be such that mouth and nostril seem but one.

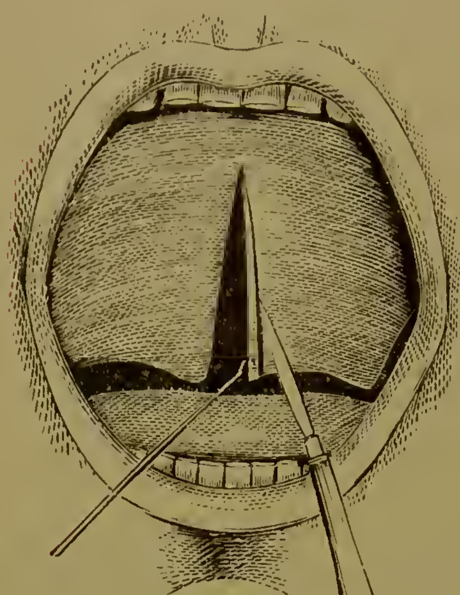


Fig. 1208.

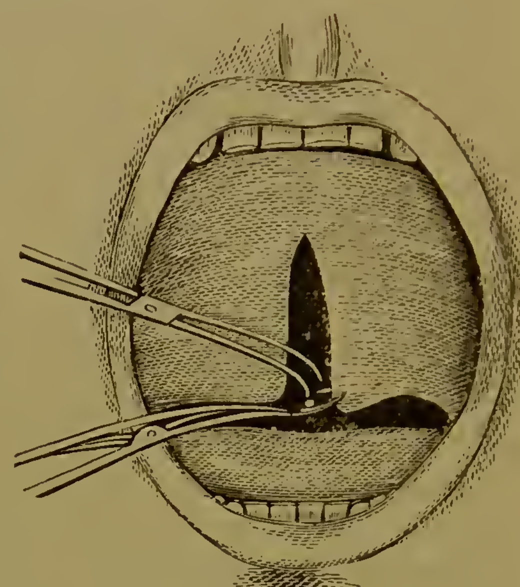


Fig. 1209.

The fissure posteriorly is *always on the median line;* anteriorly, it generally deflects to one side or the other of the nasal septum, passing also to one side of the inter-maxillary bone. In some rare cases both

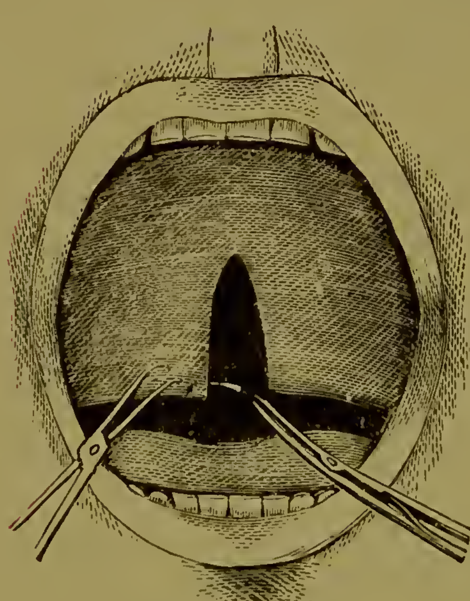


Fig. 1210.

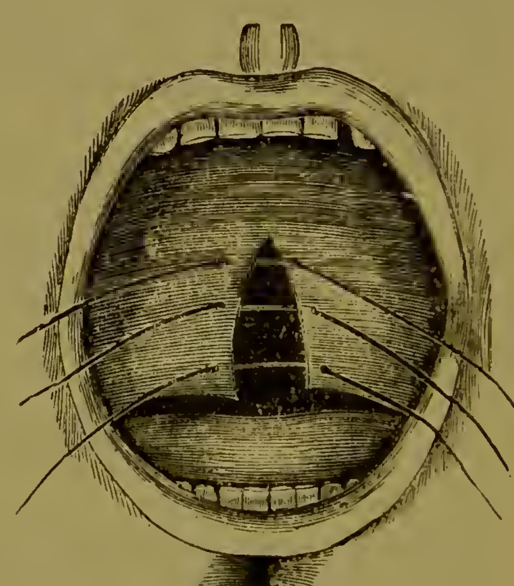


Fig. 1211.

nasal passages are involved, and a double harelip is the consequence. The effects of this condition, already stated, may thus be briefly summed up. During infancy the functions of suction and deglutition

are with difficulty performed, and at a later stage mastication and articulation are much impeded. There is also imperfect control over the muscles of the palate, both fluids and solids are liable to pass into the windpipe, and not unfrequently there is regurgitation through the nose. The speech is guttural and nasal, often so indistinct as to render it almost entirely unintelligible, and the patient is only too anxious to grasp at any chance that may be held out as being likely to grant some amelioration of his condition.

Various methods have been suggested for the cure of this deformity, such as pressure on the yielding bones in early infancy, the operation of staphylorrhaphy, and artificial substitutes; but as Dr. Kingsley remarks, the cases are very exceptional where normal articulation is ever acquired with a surgical velum—that is by staphylorrhaphy.

All the earlier operations of staphylorrhaphy consisted in paring away the edges of the cleft, and then bringing them in contact by means of sutures until union was effected. The various stages of the operation as then performed are sufficiently illustrated in the accompanying engravings, the successive steps being taken in the order of these drawings. Many modifications of this plan were made by Warren, Mettauer, Stevens, Graefe, and others; but Fergusson introduced a new principle of treatment in the operation which has very materially added to its successful results.

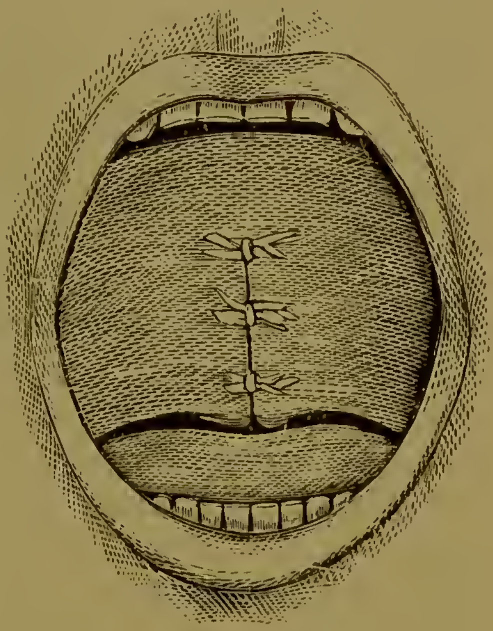


FIG. 1212.

We have alluded to the use of the muscles composing the velum of the palate and their important action on it, and to Fergusson must be assigned the credit of being the first to realize practically the fact that muscular action was the most frequent cause of failure of the operation; and he proved the truth of his conjecture by his method of removing the difficulty; namely, the division of the muscles of the palate, thus entirely paralyzing their action. Billroth more recently introduced a new procedure, which is to chisel away the lower part of the pterygoid process so as to relieve the tension produced by the tensor palati and palato-pharyngeus muscles.

Mr. Cartwright proposes the following method of treatment to prepare the patient for this operation: it has been found that the exhibition of the bromide of potassium tends to deaden the sensi-

bility of the fauces in a very remarkable manner, and thus it may become a most useful agent preparatory to the operation. If exhibited in half-dram doses, given thrice daily for two or three weeks prior to the period decided upon, but little irritability of the parts will be found remaining; and by the time a few imaginary operations on the parts have been performed, by the aid of such harmless instruments as a camel's-hair brush or the feather of a quill, the patient will be found in a fit condition to be operated upon. A few days prior to the time of operating more particular attention must be paid to the condition of the patient. Primarily, he must be well nourished, inasmuch as he will be forced to adopt a different regimen from that to which he has been accustomed for some days. His diet must be nutritious without being stimulating, and the greatest attention must be given to the regular action of the bowels, and, indeed, in all cases it is well to give a mild aperient before operating.

Sir Wm. Fergusson's Operation.—Mr. Cartwright describes Mr. Fergusson's operation as follows: He first divides the muscles of the palate by passing a curved knife around between the velum palati and the end of the Eustachian tube, thus at once dividing the levator palati. In the second stage he seizes the uvula, thus bringing forward the posterior pillar of the fauces, which is snipped across with round-pointed scissors, so as to divide the fibres of the palato-pharyngeus muscle; should it be deemed necessary to do so, the anterior pillar may be divided at the same time, so as to sever the palato-glossus, though Sir William lays no stress upon the necessity of doing so. Next the uvula is again seized, with a view of extending the palate so that the edges of the fissure may be pared away; this is accomplished with a narrow bistoury from behind forward, on either side alternately, the angle of union being left for subsequent removal. A few moments then are granted to the patient to recover, and he is permitted to swallow a few small pieces of ice, with the double view of refreshing him and of staunching the bleeding. When this has sufficiently ceased, it is time to introduce the sutures, and this is done by means of a nævus needle, armed with a silken ligature (silk-worm gut is preferable for ligatures), the needle being introduced about a quarter of an inch from the edge of the fissure. Next, the extremity of the thread is pulled out by means of forceps, and another ligature is passed in like manner, until the desired number of stitches is attained. The extremities must then be tied loosely, so as just to keep the parts in apposition and no more; after which the patient is put to bed, every care being taken to avoid all motion of the palate. He should take nothing but nourishing liquid food for a few days, and must be particularly enjoined to abstain from all movements involving action of

the muscles engaged in deglutition, such, as swallowing, coughing, sneezing, and the like, which would much endanger the success of the operation. The next stage consists in the removal of the stitches; this need not be done too soon, provided they produce no irritation; indeed, they may remain until union is perfect. The general time for their removal is about the seventh or eighth day, although Fergusson often removes them on the third or fourth.

Mr. G. Pollock has introduced the following modifications in the performance of this operation: Instead of dividing the muscle with a curved knife from behind, according to the method we have just described, Mr. Pollock passes a ligature through the soft palate, so as to contract and draw it forward, and he then pushes a narrow-bladed knife through it, a little to the inner side of the hamular process of the ptergyoid plate of the sphenoid bone, which may be plainly discovered by passing the finger along the roof of the mouth to a distance a little posterior to the tuberosity of the superior maxilla. By raising the hand, and so depressing the point of the scalpel, he most effectively, and in a very simple manner, divides the muscle. The parts having healed, the patient must be impressed with the necessity of practicing himself frequently in elocution, telling him that his success in articulation will depend upon himself alone. Constant, patient, persevering effort will be necessary, and the end to be attained must be sought by distinctly articulating every syllable of every word which he may be called upon to utter. It is a good exercise to read a portion of some good author each day with a friend, who will assume the role of schoolmaster for the time being, permitting no word to be indistinctly uttered or slurred over and requiring each syllable to be correctly and separately pronounced.

Fissure of the hard palate, simple or connected with a fissure of the soft. Various means of closure have been proposed. Dr. Warren dissected the mucous membrane from the bone on either side, carrying his knife sufficiently forward toward the alveolar border to form a flap broad enough to meet a like one from the opposing side along the median line. When the fissure is so wide as to prevent the margins being brought together, Dr. Mettauer, of Virginia, recommended making several lateral incisions through the mucous membrane, with a view of permitting the edges to be brought into close apposition. Dr. Mütter, of Philadelphia, who was very successful in the operation, also had recourse to the longitudinal incision (as shown by Fig. 1213), which was first proposed by Dieffenbach, with happy results. Dr. Warren's operation has been introduced into England by Mr. Pollock, who, with his peculiarly constructed instruments, proceeds as follows: He makes an incision along the edge of the cleft at the juncture of the

nasal and palatal mucous membrane. The soft covering of the hard palate is carefully dissected or scraped from the bone with curved knives, great care being taken that the mucous membrane and its subjacent fibrocellular tissue are not perforated. When this has been well loosened on either side, it will be found to hang down like a curtain from the vault of the mouth, the two parts coming into apposition along the median line, or possibly overlapping. The edges, being then smoothly pared, are brought together by means of a few points of suture introduced in the ordinary way and without any dragging. Where the hole is not very large, Dr. Pancoast's operation of staphyloplasty may be performed, in which he raises two flaps of mucous membrane from the bone on either side, and then, reflecting them across the chasm, their edges are brought together by suture in

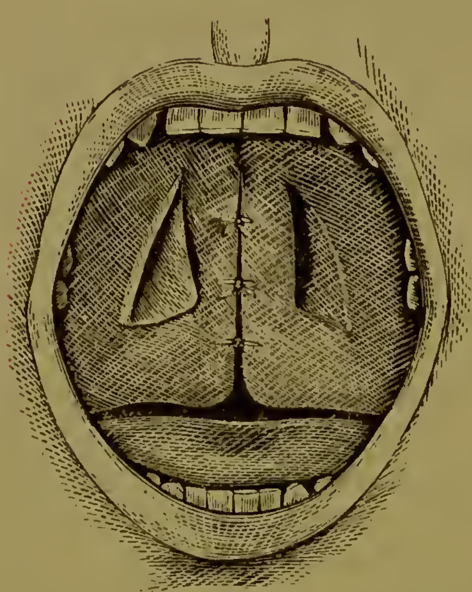


FIG. 1213.

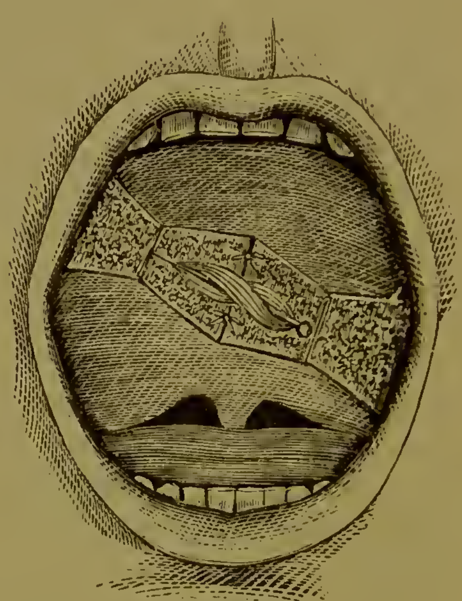


FIG. 1214.

the usual manner, a plan which is so perfectly exhibited in Fig. 1214 that we do not deem any further description necessary. M. Langenbeck suggested another operation, in which he proposed to dissect the mucous membrane, together with the periosteum, from the surface of the bone prior to bringing the opposed surfaces of the cleft in apposition; and the advantages claimed by him for this, which he considers to be a novel method of procedure, is that the chasm is obliterated, not merely by soft tissue, but by bone, which is formed from the periosteum thus loosened from contact with the surface of the hard palate. Dr. T. W. Brophy has recently suggested the following operation: "Vivify the edges of the fissure thoroughly and with a bold hand. On the hard palate trim the opposing surfaces of the bone as well; the knife will easily cut through the soft bone of the hard palate and

the alveolar process. The fissure is then brought together by wire sutures passing through a lead button and the body of the maxilla above the palatal bone, then tightened by twisting until the parts are in contact. In some cases the maxillæ are divided horizontally beneath the malar process. If the resistance is such that the edges do not readily approximate, the malar process is divided on either side by the aid of a heavy scalpel."

There are many cases of abnormality in the os palati which can only be relieved by mechanical appliances, and this relief can be afforded in a most satisfactory manner, no more inconvenience being felt by the patient than he would experience in wearing an artificial denture, with which the false palate could be connected, were it necessary to do so. Artificial aid has been several times alluded to in reference to the operation of staphylorrhapy; but it is now a well established fact, that in the large majority of cases a scientifically constructed artificial velum will prove satisfactory. The main and only object is to give to the afflicted the power of articulate speech, and this, as Dr. Kingsley remarks, can only be produced normally by voluntarily opening and closing the passage from the larynx to the nose. If this cannot be accomplished, because of the inability of the palate to act, speech will be defective. Undoubtedly, the operations which have been described are often, as far as mere union is concerned, most satisfactory in their results; but there are other considerations besides these. Naturally the chief desire of the patient is to take a footing in society on equal terms with other men; and there are no means which will enable him to do so, unless they can restore to him his lost or impaired power of speech—that divine gift which places man so immeasurably above the brute creation. This has been almost lost in many cases of cleft palate; and it is the great object of treatment to put the sufferer in a way of uttering his thoughts in plainly-spoken words like those around him; whatever means are best calculated to bestow this inestimable benefit are those which the conscientious surgeon ought to select.

There are certain cases where the opening is not large, and as there is little tension of the parts the opposite sides come together in close proximity; staphylorrhaphy may here be performed with good results, for it must be recollected that it is always a desideratum to avoid the presence of foreign substance as a substitute for natural tissues, if these are equally effective. Allusion has been made to the liability to injury of the parts by a division of the muscles. Where an artificial palate is used the muscles are unimpaired; and it is claimed that persons who when without the instrument could not be understood, spoke fluently and distinctly the

moment they introduced it into their mouths. So far as the discomforts of wearing such an apparatus are concerned, after a short time the wearers become entirely unconscious that they are wearing anything artificial.

OBTURATORS AND ARTIFICIAL PALATES.

We have classified palatine defects as accidental and congenital; we shall also classify the appliances used for their remedy. The term *obturator* will be used for all instruments intended to stop or cover all those openings in the hard or soft palate which have a well defined border or outline. The term *artificial velum* is applied to a mechanical contrivance which consists of an elastic, movable valve which is under the control of adjacent or surrounding muscles and capable of closing or opening the posterior nares at will, and which is applicable to cases of congenital cleft-palate, and also in certain cases, when the soft palate has been destroyed by ulceration.

Any unnatural opening between the oral and nasal cavities which will permit the free passage of the breath will impair articulation. Any appliance which will close such passage and can be worn without inconvenience will restore articulation.* Obturators were formerly made of metallic plate, gold or silver being most commonly employed, and many very ingenious pieces of mechanism were the result of such efforts; but latterly vulcanized rubber has almost entirely superseded the use of metals. Vulcanite has been found preferable to metals, being much lighter and much more easily formed and adapted, particularly when of peculiar shape. In regard to the age of the patient which is most suitable for the application of an artificial velum, Dr. Kingsley remarks that for some thirty years past he has been applying such contrivances repeatedly for children under ten years of age.

Bourdet was the first who proposed to employ simply a metallic plate fitted to the vault of the palate and large enough to cover the opening, with two lateral prolongations, one on each side, extending to the teeth, to which they are fastened by means of ligatures. This was also found to be objectionable, as the ligatures were productive of constant irritation to the gums; moreover, they did not hold the plate in place with sufficient stability, and its use was soon abandoned. But these objections were both obviated by an improvement made by M. Dela-

* The student will bear in mind that no cognizance is here taken of openings similar to those described in cases of congenital fissure, where the surgeon has united the soft palate, and left an opening through the hard palate to be covered by an obturator.

barre, which consisted in the employment of clasps, instead of ligatures, attached to lateral branches of the plate. To prevent these from slipping too high up on the teeth he attaches to each a kind of spur, which was so bent as to come down over the grinding surface of the tooth to which it is applied. The last-named author also made another modification, which consisted in the application of a drum to the upper surface of the plate (Fig. 1215). The object of this was to prevent the accumulation of mucous fluids from the nose in the *cul-de-sac*, formed by simply closing the opening below; also to prevent fluids, in swallowing, from passing up between the obturator and the soft parts through the opening into the nose. The drum evidently offers the same impediment to nature's efforts in closing the opening as the obturator before mentioned; on this score, therefore, it is equally objectionable.

When the opening in the palate is small, and has *no connection with the velum*, it is unnecessary to raise the upper surface of the plate by

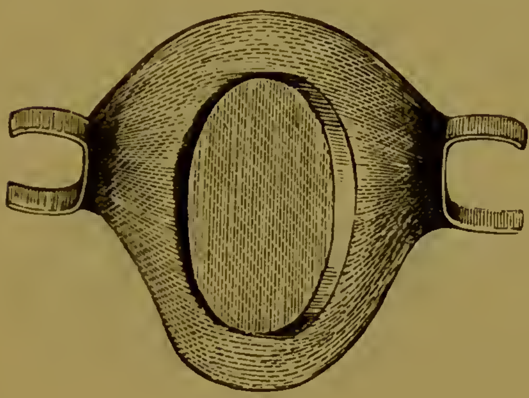


Fig. 1215.

Fig. 1216.

attaching a drum or air chamber to it. If it be accurately fitted to the vault of the palate, it will effectually prevent fluids, in deglutition, from passing up in the nasal cavities, or the escape of any portion of the voice through the opening; also by frequently removing the plate the accumulation of the secretions in the *cul-de-sac* will be prevented. A simple plate, like the one represented in Fig. 1216, will be all that is required to remedy the defect; and this, in fact, will probably be found the best form in all cases, whether the openings be large or small.

Fig. 1217 represents an obturator without teeth and without clasps for a perforation of the hard palate, being sustained *in situ* by impinging upon the natural teeth with which it comes in contact. Accuracy of adaptation and delicacy in form are all that is essential in such cases, and the restoration of the speech will follow immediately.

A clumsy contrivance will interfere with articulation almost as much

as it is improved by stopping the opening; therefore, if the obturator could be confined entirely to the opening, like a cork in a bottle, it would be more desirable. As this cannot be, resort must be had to clasping the contiguous teeth, if there are any; if there are none, the obturator must extend over the whole jaw and receive its support in the same manner as would a set of artificial teeth. In fact, this is precisely what it becomes in such a case—an upper set of teeth bridging over and filling up an opening in the palate, thus combining an obturator, with a denture. Fig. 1218 represents a more complicated obturator, adapted to an opening in the soft palate. The necessity for a variation in the plan will be found in the anatomical fact of the constant muscular action of the soft palate, which would not permit, without irritation, the presence of an immovable fixture. This is contrived, therefore, with a joint, which will permit the part attached to the teeth to remain stationary, while the obturator proper is carried up or down as moved by the muscles. The joint, A, should occupy the

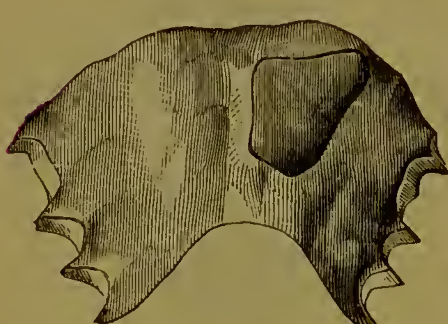


FIG. 1217.

FIG. 1218.

position of the junction of the hard and soft palates. The joint and principal part of the appliance is made of gold, the obturator of vulcanite. The projection, B, lies like a flange upon the superior surface of the palate and sustains it; otherwise the mobility of the joint would allow it to drop out of the opening. This flange is better seen in the side view, marked C. It is readily placed in position by entering the obturator first, and carrying the clasps to the teeth subsequently.

Figs. 1217 and 1218 will illustrate the essential principles involved in all obturators. The ingenuity of the dentist will often be taxed in their application, as the cases requiring such appliances all vary in form and magnitude. The steps to be taken in the formation of an obturator are not unlike those used in making a base for artificial teeth. It is essential that an accurate model be obtained of the opening, the adjacent palatal surface, and the teeth, if any remain in the jaw. For this purpose an impression taken in plaster is the only kind to be relied upon. Care must be used that a surplus of plaster is not forced

through the opening, thus preventing the withdrawal of the impression by an accumulated and hardened mass larger than the opening through which it passed. To avoid this, beginners or timid operators had better take an impression in the usual manner with wax. If this is forced through, it can be easily removed without injury to the patient. From this wax impression make a plaster model, and upon this plaster model form an impression cup of sheet gutta-percha, using a stick, a piece of wire, strip of metal, or any other convenient thing for a handle. This extemporized impression cup must not impinge upon the borders of the opening, neither should it enter to any extent. With a uniform film of soft plaster, of from one-sixteenth to one-eighth of an inch in thickness, laid over this cup a correct impression can be taken without any surplus to give anxiety. Upon a correct plaster model taken from such an impression the obturator should be molded out of gutta-percha or any other plastic substance, the subsequent steps being in principle the same as in making any other piece of vulcanite. It is desirable that it should enter the perforation and restore, as far as possible, the lost portion of the palate; but it must not intrude into, or in any way obstruct, the nasal passage. *The entire freedom of the nasal passage is essential to the purity of articulation.* That portion of the obturator which occupies the oral cavity should be made as delicate as possible, consistent with its strength and durability.

ARTIFICIAL PALATES.

Before proceeding to a description of artificial palates, a brief reference to the anatomical relations and functions of the *velum palati* will be necessary. The palate exercises quite as important an office in the articulation of the voice as does the tongue or lips. Being a muscular and movable partition to separate the nasal and oral cavities, one edge is attached to the border of the hard palate, while the other vibrates between the pharynx and the tongue. The voice, therefore, as it issues from the larynx, is directed by the palate entirely into the mouth or through the nose, or permitted to pass both ways.

A very slight deviation in this organ from its natural form will make the voice give a different sound; so the presence of anything that clogs the natural passages, either oral or nasal, modifies the vocal vibrations. Place any obstruction in the nasal passages, paralyze the soft palate, or let it be deficient in size, and the power of distinct articulation is wanting. Evidence of this statement is very frequently found after the surgeon has successfully performed the operation of staphylorrhaphy in case of congenital fissure. In such instances (with rare exceptions) the newly-formed palate is so deficient in length and so tense as to be deprived of its function. It cannot be raised so as

to meet the pharynx and shut off the nasal passage, but hangs like an immovable septum to divide the column of sound.

Fig. 1219 represents a defective palate belonging to the first class, the uvula and a portion of the contiguous soft palate being destroyed by disease. In such a case an obturator would be useless; the constant activity of the surrounding parts would not tolerate it. The material used for a substitute must be soft, flexible, and elastic; and the elastic vulcanite is admirably adapted to this purpose.

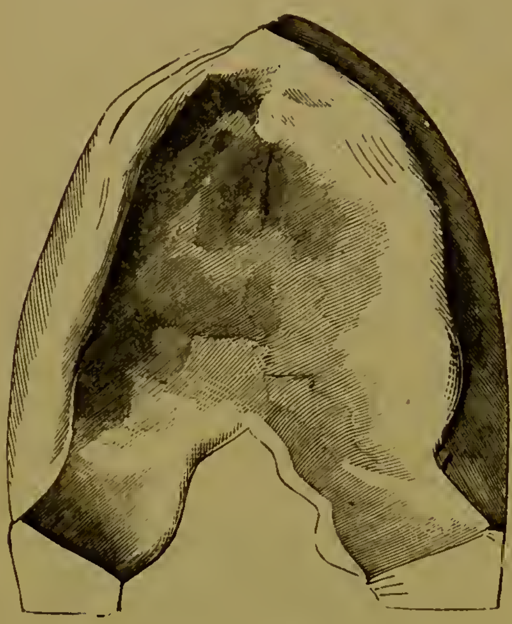


Fig. 1219.

By observing the cut (Fig. 1219), it will be seen that a portion of the soft palate along the median line remains, and consequently there will be considerble muscular movement which must be provided for and which may be taken advantage of. It is desirable to make this movement available in using an artificial palate, as thereby more delicate sounds are produced than otherwise.

This case presented some extraordinary difficulties in the fact that all the teeth of the upper jaw had been extracted; and it was necessary, therefore, to adapt a plate which should not only sustain the teeth for mastication, but bear the additional responsibility of supporting the artificial palate. In the choice of material best adapted as a base for the teeth in such instances, it is preferable to adopt that which will prove the most durable. There are too many interests involved to risk the adoption of anything but the best. In the case under description the patient desired duplicates, and two sets of teeth were made, one on gold and the other on platina, with continuous gum. The plates were made like other sets of teeth, with the exception of a groove located on the median line at the posterior edge to receive the attachment for the palate (marked C in Fig. 1220).

Fig. 1220 will indicate the set of teeth with palate attached. The wings, marked A and B, are made of soft rubber; the frame to support them is made of gold, with a joint to provide for the perpendicular motion of the natural palate, as in the case of the obturator represented in Fig. 1218.' When the artificial palate is in use, the joint and frame immediately contiguous lie close to the roof of the mouth; the rubber wing, letter A, bridges across the opening on the inferior

surface of side next the tongue; the wing, letter B, bridges across the opening on the superior or nasal surface, and is also prolonged backward until it nearly touches the muscles of the pharynx when they are in repose.

Both these wings reach beyond the boundary of the opening and rest on the surface of the soft palate for a distance of from one-eighth to one-quarter of an inch, thus embracing the entire free edge of the

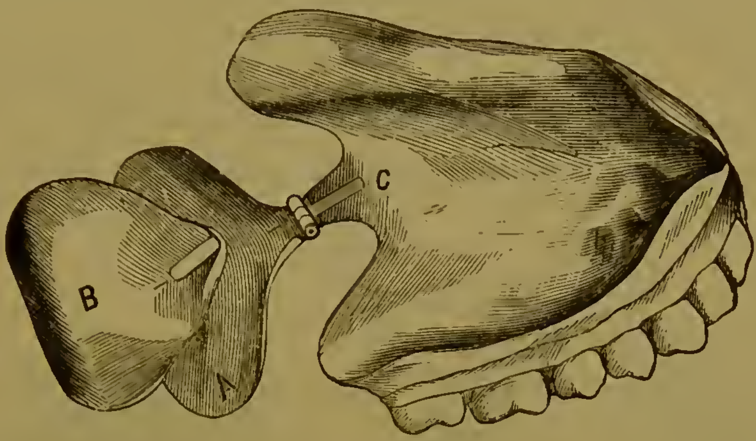


FIG. 1220.

soft palate. This last provision enables the natural palate to carry the artificial palate up or down, as articulation may require.

When the organs of speech are in repose there is an opening behind the palate sufficient for respiration through the nares. When these organs are in action, a slight elevation of the palate or a contraction of the pharynx will entirely close the nasal passage and direct all the voice through the mouth. The palate thus becomes a valve to open or close the nares, and to be tolerated must be made with thin, delicate edges which will yield upon pressure. An instrument thus made will restore, as far as possible by mechanism, the functions of the natural organ.

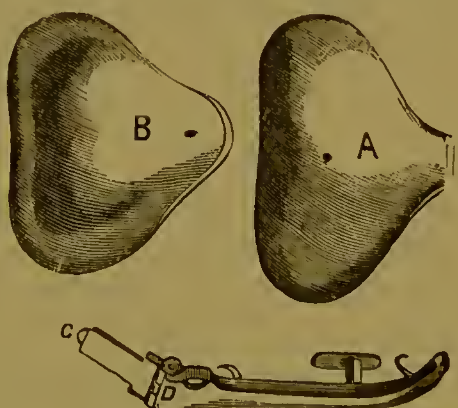


FIG. 1221.

Fig. 1221 represents the artificial palate separated into its constituent parts. The frame is bent at the joint in the engraving to show a stop marked D, which prevents the appliance from dropping out of position. Letter C shows the tongue, which enters the groove in the plate of teeth and connects them. Letters A and B are the rubber flaps, which are secured to the frame by the hooks, as seen in the engraving. The process for making rubber wings will be found described on page 1155.

Fig. 1222 shows a more extensive palatine defect of the first class.

In this case the entire soft palate is gone, together with a small portion of the hard palate at the median line. Although this defect is greater in extent, the means for its remedy are more simple. The muscles of the palate are entirely gone, and, consequently, no perpendicular movement need be provided for. The appliance in this case will resemble an elastic obturator more than the valve-like palate of the preceding one. The principle here adopted is substantially that recommended by Mr. Sercombe, of London, some years since, and consists of a plate with a set of teeth in the usual form, and attached to its posterior edge an apron of soft rubber, which shall bridge the opening on its inferior surface, extending nearly to the pharynx. Fig. 1223 represents the set of teeth with the palate attached. In Mr.

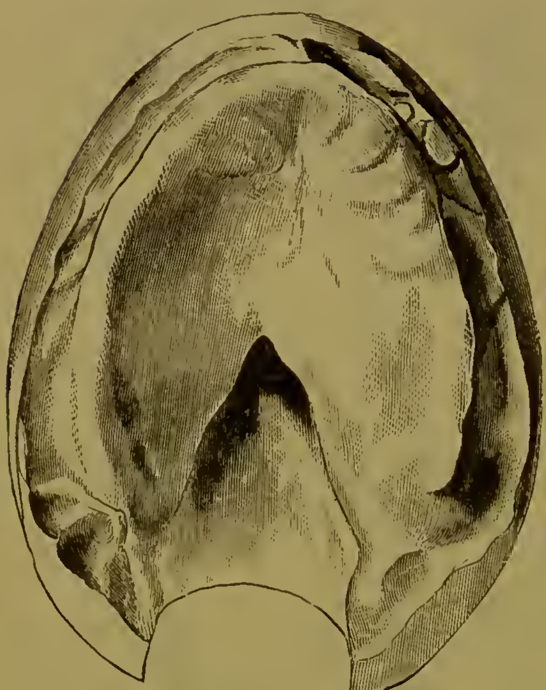


FIG. 1222.

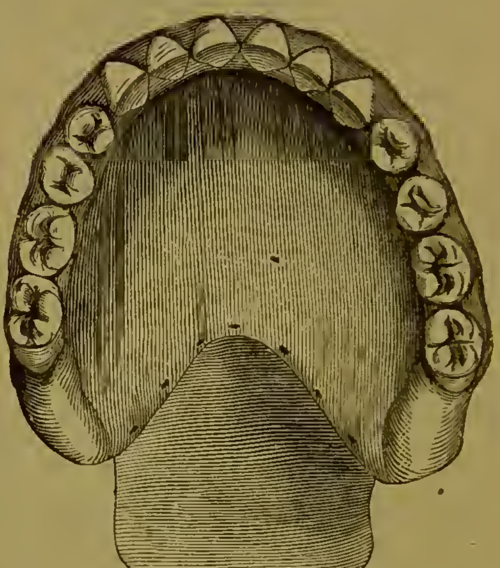


FIG. 1223.

Sercombe's appliance this apron was made of the common sheet rubber in the market, prepared for other uses, and is objectionable for two reasons: 1st. A want of purity in the materials of which it is compounded, in many instances substances being used in its manufacture which would prove deleterious to the health of the patient; and, 2, its uniformity of thickness. It is far preferable, therefore, to make a mold from which to form a palate of pure and harmless materials, one which shall be of sufficient thickness in the central part and at its anterior edge to give stability, and yet shall have a thin and delicate boundary wherever it comes in contact with movable tissue. Such a palate may be made in a mold by substantially the same process as hereafter described. (See page 1155.) It may be

secured to the plate by a variety of simple means. One, which will give as little trouble to the patient as any other, is to make a series of small holes along the edge of the plate and stitch it on with silk, or fine platina, gold, or silver wire may be used. It is desirable in this case to have the plate and palate present a uniform surface on the lingual side. In fitting the plate, therefore, it may be raised along the posterior edge from the sixteenth to the tenth of an inch, according to the thickness of the palate desired. The rubber will thus be placed on the palatine surface of the plate and present uniformity on the lingual surface.

A little thought will show that in this case the patient must educate the *muscles of the pharynx alone* to do the work of shutting off the nares, which, in the former case, was performed by them in conjunction with the muscles of the palate. Perfection of articulation will, therefore, depend upon the success of the patient in this new use of these muscles.

In cases of accidental lesions of the palate, such as are under consideration, this education of the muscles to a new work will not be difficult. The patient at some former time has had the power of distinct articulation; his ear has recognized in his own voice the contrast between his present and former condition; the ear will therefore direct and criticize the practice until the result is attained.

In the case illustrated by Fig. 1222, the defect had existed for twenty-eight years, the patient, at the time of the introduction of the artificial palate, being nearly fifty years of age. The effect upon the speech was instantaneous. Articulation was immediately almost as distinct as in youth; and this remarkable distinctness can only be accounted for upon the assumption that the pharyngeal muscles had undergone a thorough training in the vain effort to articulate without any palate.*

These two cases, chosen to illustrate the application of artificial palates in accidental lesion, have required, as will have been perceived, entire upper sets of artificial teeth in connection with the palates. This selection was purposely made because the difficulties to be overcome are much greater. In cases where there are natural teeth remaining in the upper jaw, the palate and its connection with a plate would be substantially the same, and the plate might easily be secured to the teeth by clasps, in the same manner as a partial denture.

Artificial Palates for Congenital Fissure.—Congenital fissure of the

* An account of this case appeared in the *Argus*, of Bainbridge, Georgia, August 1st, 1868, written by the patient himself, who was the editor of that paper.

palate presents far greater difficulties to be overcome than cases of accidental lesion. The opening is commonly more extensive, the appliance more complicated, and the result more problematical. Nevertheless, appliances have been made in a large number of cases which have enabled the wearers to articulate with entire distinctness, so much so as not in the least to betray the defect.

The first efforts made in this direction resembled obturators. They were simply plugs to close the posterior nares, and the results were far from satisfactory. It was not until it was recognized that the two classes of cases, accidental and congenital, were entirely distinct, that much progress was made.

Nearly every case of accidental lesion can be treated by an obturator with considerable success; but very rarely will an obturator be of any benefit in congenital fissure, even if the congenital and accidental cases present substantially the same form of opening. For this reason much embarrassment has been thrown around these appliances within a few years past. *The character of the different classes has been confounded, and an instrument admirably adapted to one class has had claimed for it an equal application to the other class.* Let it be understood, therefore, as a rule to which there will be but few exceptions, *that congenital fissure of the soft palate requires for its successful remedy a soft, elastic, and movable appliance;* and that, with the most skillfully made instrument, *vocal articulation must be learned* like any other accomplishment. Various inventions have been made for this purpose within the last twenty-five years, from the most complicated one of Mr. Stearns, described in a former edition of this work, to the extremely simple one of bridging the gap with a single flap of rubber. The Stearns instrument, with all its complexity, embodied the only true principle, viz., *rendering available the muscles of the natural palate to control the movements of the artificial palate.*

The essential requisites of an artificial palate are (1) to replace, as far as possible, the natural form of the defective organs (2) with such material as shall restore their functions. Muscular power certainly cannot be given to a piece of mechanism, but the material and form may be such that it will yield to, and be under the control of, the muscles surrounding it, and thus measurably bestow upon it the function of the organ which it represents.

Fig. 1224 represents a model of a fissured palate, complicated with harelip on the left of the median line. There is a division also of the maxilla and alveolar process; the sides, being covered with mucous membrane, lie in contact with each other, but they are not united. If it is desired, a very simple surgical operation can be performed which will unite both soft and hard tissues at this point of division.

The left lateral incisor and left canine tooth are not developed. Fig. 1225 represents the artificial velum as viewed upon its superior surface, together with the attachment of a plate containing a clasp and two artificial teeth to fill the vacancy.

The lettered portion of this appliance is made of elastic vulcanized rubber; its attachment to the teeth, of hard vulcanized rubber, to

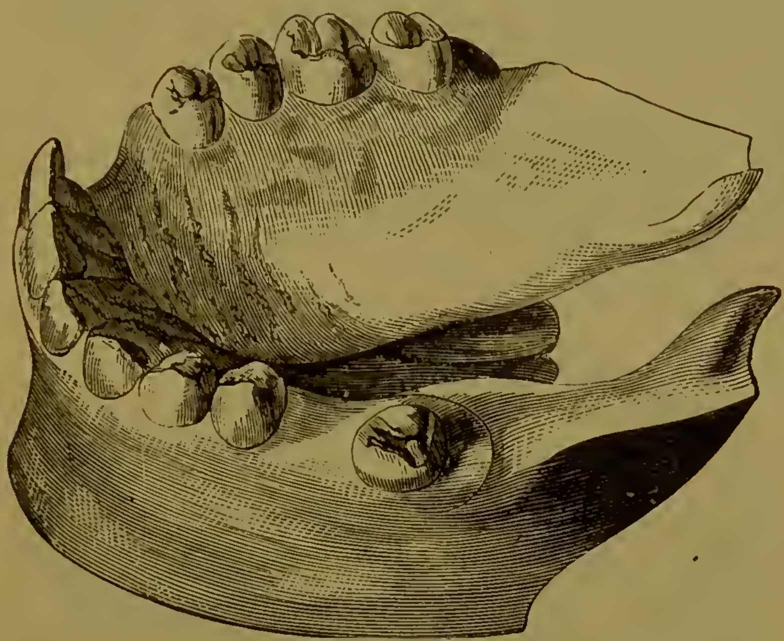


FIG. 1224.

which the velum is connected by a stout gold pin, firmly imbedded at one end in the hard rubber plate. The other end has a head, marked C, which, being considerably larger than the pin and than the corresponding hole in the velum, it is forced through—the elasticity of the velum permitting—and the two are securely connected. The process

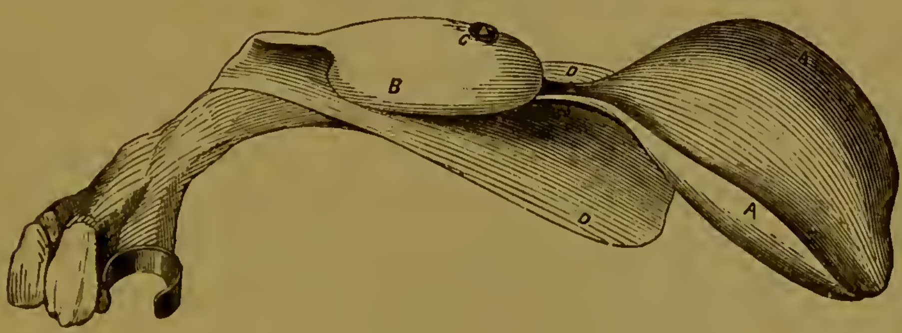


FIG. 1225.

B laps over the superior surface of the maxilla (the floor of the nares) and effectually prevents all inclination to droop. The wings, A, A, reach across the pharynx, at the base of the chamber of the pharynx, behind the remnant of the natural velum. The wings, D, D, rest upon the opposite or anterior surface of the soft palate.

Fig. 1226 represents a model the same as Fig. 1224, with the appliance, Fig. 1225, *in situ;* the wing, D, D, in Fig. 1225, and the posterior end of the artificial velum, A, alone being visible in this figure.

The reader will bear in mind that the essential characteristics of this appliance are a soft, elastic substance filling the gap in the soft palate, with a flap behind as well as before, which enables it to follow all movements of the muscles with which it comes in contact, and thus perform, to a very considerable degree, the function of the fully developed natural organ.

It is this characteristic alone which made the Stearns palate a success, and to produce which result Stearns invented the complicated and, for most cases impracticable, machinery as shown in Figs. 1233

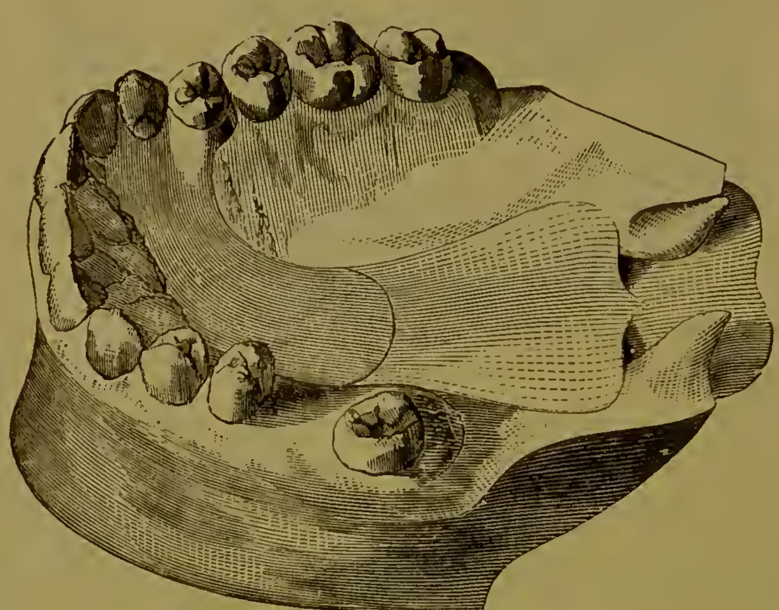


FIG. 1226.

and 1234. It was to produce the same effect by a simple appliance that the writer labored unremittingly for more than ten years, the appliance of to-day being no modification in any sense of the Stearns instrument, nor of that of any other author, but an individual and separate invention, so very simple that we can conceive of no different way by which perfection of result can be so nearly attained. A hundred instruments of like character now being successfully worn attest the writer's confidence in it. Simplicity has gone but one step further, and that has been to leave off entirely the posterior flap marked A, A in Fig. 1225. This has been done in England, France, and Germany, and occasionally in our own country, and a parade made of the fact. as an improvement on the inventions of the writer ; but the experience of the past shows that in all these cases the makers have failed to com-

prehend the requirements of the case, and have, in attempting to improve the instrument, dispensed with one of its essential characteristics.

A later invention, and one which the author believes to be of almost universal application, is represented in Fig. 1227. To appreciate the importance of this invention it must be borne in mind that heretofore an instrument peculiar in form has been required for every separate case. Each appliance, being made in a mold of special adaptation, has therefore entailed upon the operator a large amount of labor.

With this later invention it is believed that with a few molds, producing a limited variety of palates adapted to the leading features in such cases, nearly every case of congenital cleft can be provided for upon the same principle as other forms of surgical appliance are made for general use. It was only after years of experience and the obser-

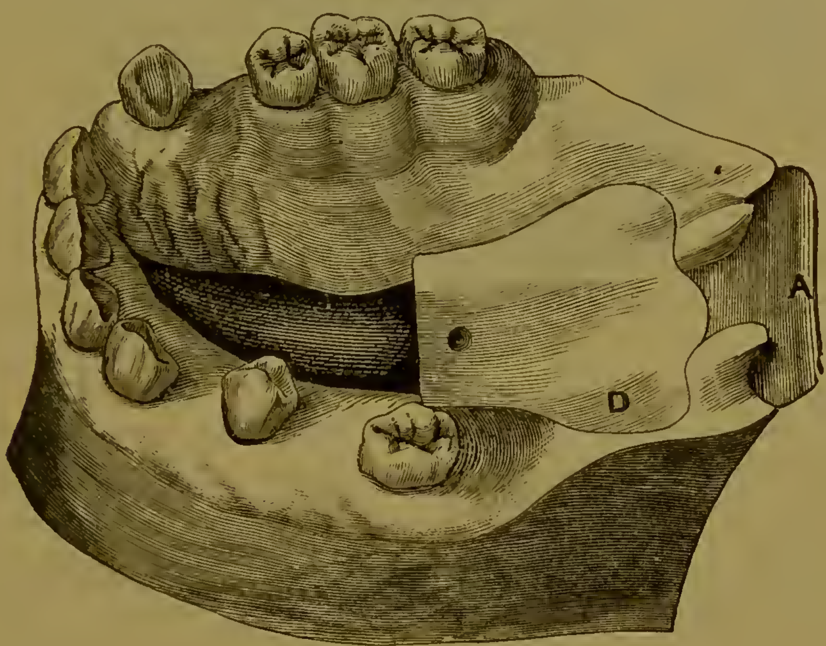


FIG. 1227.

vation of many cases that the characteristics which were common to all could be determined.

Those common features are: (*a*) The fissure through the soft palate is always in the median line; (*b*) the variations, if any, from the median line are anterior to the soft palate in the palatine and maxillary bones; (*c*) thickness of the border of the fissure in the remnant of the soft palate is generally uniform; (*d*) the sides correspond very nearly with each other in length, breadth, thickness, and contour; (*e*) the chief variation in nearly all clefts of the soft palate is in their size or breadth, and this is true without any reference as to whether the fissure extends forward into the hard palate or not. Figs. 1224 and 1227 represent two cases of remarkable general likeness, although

they differ twenty years in age and more than five years in the period of time at which they were treated.

The palate placed *in situ* in Fig. 1227 shows an instrument which, with variations in size, is of almost universal application. It is nearly identical with the palate, Figs. 1225 and 1226, were that one cut across the middle. Like the other, it is made of soft rubber, and, moreover, it will need an additional fixture to fill the gap in the hard palate and also keep the artificial velum from being swallowed. In Fig. 1225 there is a projection marked B, which is made of soft rubber and is a part of the velum. This projection, as has already been noticed, is intended to assist in supporting the velum in position. This is not always necessary or desirable; there are cases where the velum is quite as well sustained without this projection, and where, if it were applied, it would certainly injure the tone of the voice by clogging the nasal passage. In the case of Fig. 1227, if support were desired by lapping on the floor of the nares, toward the apex of the fissure, it would form a portion of the hard palate or obturator instead of being part of the velum or soft palate as heretofore.

OBTURATORS AND PALATES COMBINED.

We shall proceed now to consider another class of cases, the proper treatment of which has been followed by the most encouraging results.

For fifty years the operation of staphylorraphy has been a favorite one with surgeons, yet the number of cases in which there has been only a partial union are largely in the majority. In many instances all that has been accomplished is simply the tying together of a small portion of the soft palate across the back part of the fissure, leaving an opening of greater or less size through the hard palate, anterior to the newly formed septum. This opening has generally been plugged with an obturator, but vocal articulation has been little, if at all, improved. To meet this emergency a new form of artificial velum was invented. Fig. 1228 will illustrate such a case with the obturator and artificial palate *in situ*.

The patient was a man fifty years of age. The operation of staphylorraphy had been performed twenty years previously; an obturator of silver, and afterward one of vulcanite, has been worn constantly ever since. Nevertheless, the articulation was not benefited, the reason being the same as in every other case of staphylorraphic operation, the new fleshy palate, marked A, not being long enough to close by any muscular effort the passage to the nares. There was, however, some remaining muscular action, to utilize which power was the desired object to be attained. Letter B, shows the obturator, the letter C, the velum. In this instance the obtu-

rator is made of soft rubber, the same as the velum, and when in use the velum is but an extension of the natural palate, as seen in Fig. 1228.

Fig. 1229 shows the appliance when not in use. The plate, D, secures the obturator to the teeth, as in other cases of artificial palates. In order to introduce the piece, the broad flap, C, should be first passed through the opening in the roof and pushed back; the

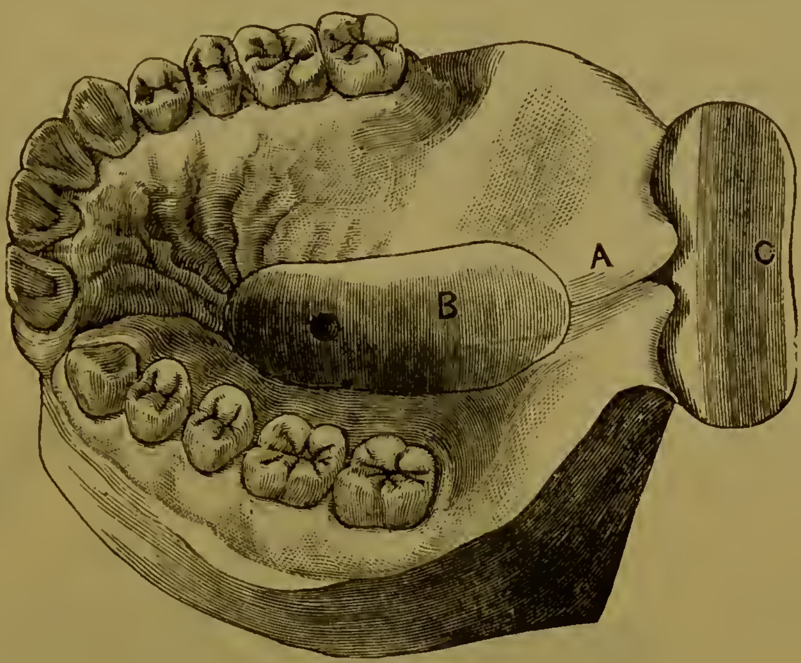


FIG. 1228.

whole fixture will readily fall into correct position. In the case of this patient, the improvement in vocal articulation was immediate and very decided.

Fig. 1230 illustrates another case of a similar character, but with incidental circumstances much more interesting. The patient was a lady, sixty-two years of age, for whom staphylorraphy was performed in 1845, by a distinguished surgeon, and the result was a remarkable success, so far as the union of the parts was concerned. The union was perfect throughout the entire length of the fissure, including the uvula; but although the patient had applied herself diligently to

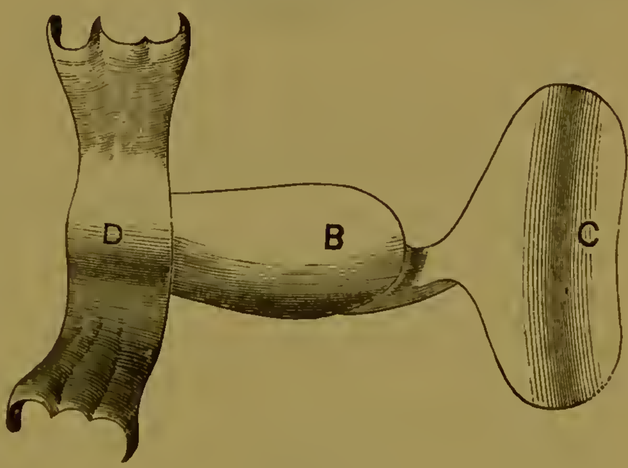


FIG. 1229.

the improvement of her speech, she was unsatisfied with her progress. The fault being the same as in all other cases—too short a palate—

the remedy must be the same. But here arose another difficulty. There was no opening through the roof of the mouth, as in case of Fig. 1227, and there was no method of securing the desired palate extension to the inferior surface of the natural palate. To convey to the artificial velum the action of the levatores palati was essential to success. After consultation with a skillful and distinguished surgeon of this city (Dr. George A. Peters, New York), it was decided to undo, in a measure, the operation of twenty-five years before, and an opening was made through the soft palate on the median line immediately behind the hard palate, as shown in Fig. 1230. The opening was a simple straight incision, which was subsequently enlarged by wearing a tent for a short time. There was no

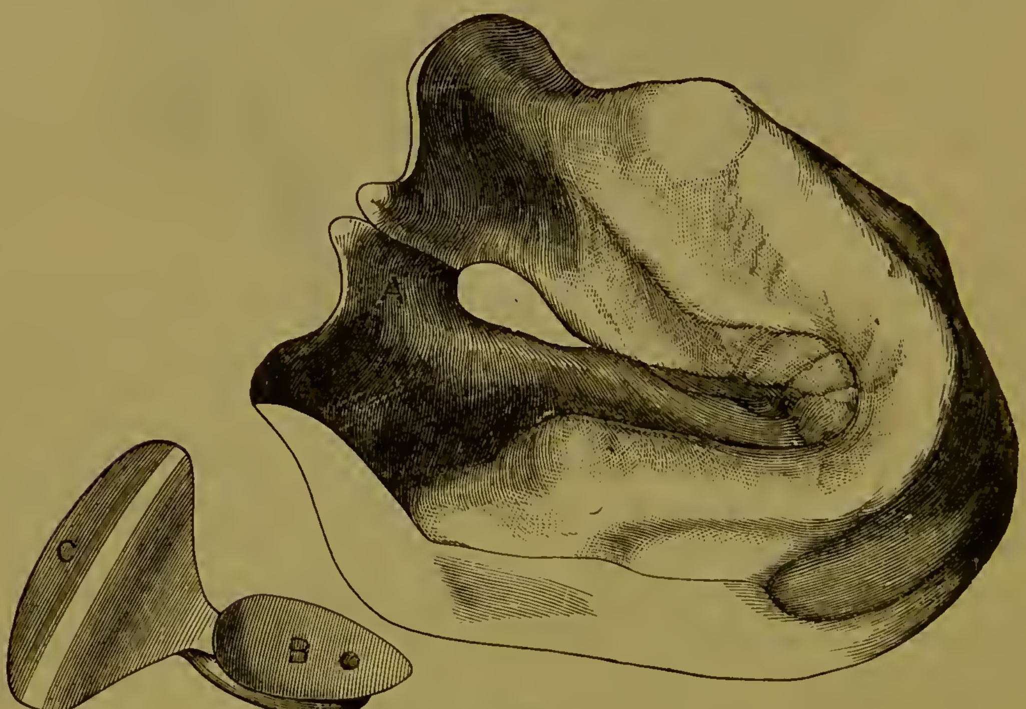


FIG. 1230.

pain; but little bleeding; and in a few days it was entirely healed. What complicated the case still further was the loss of all the teeth in the upper jaw, and an entire upper denture had been worn for years. The artificial palate was attached to such a denture, and, instead of proving detrimental to the denture, it was an advantage, serving, when in place, to keep the back edge of the plate from the possibility of dropping. The marked improvement in articulation and the gratification of the patient were a sufficient justification for the partial undoing of such an admirable surgical operation.

The later experience of the writer favors the idea of a partial staphylorraphic operation, with a view of making a narrow bridge across the posterior part of the fissure. Even the tying of the bifurcated

uvula together would be of far more service to the patient than a union throughout the length of the cleft. Such a slight bridge of the gap is more easily and certainly obtained than when greater attempts are made; as the surgical operation can be supplemented by an artificial velum of a very simple character, the patient thus derives the highest benefit which surgical skill can at this day give.

Method of Making an Artificial Palate.—The success of these appliances depends very much upon the perfect accuracy of the model, since it is upon this that the parts are molded. It is essential that the entire border of the fissure, from the apex to the uvula, should be perfectly represented in the model, as these parts are when in repose. It is also necessary that the model show definitely the form of the cavity above, and on either side of, the opening through the hard palate, since that part of the cavity is hidden from the eye. It is desirable, although it is not essential, that the posterior surface of the remnant of the soft palate be shown; but it is especially important that the anterior or under surface be represented with relaxed muscles, and in perfect repose. The impression for such a model must be taken in plaster; it is the only material now in use adapted to the purpose. An ordinary britannia impression cup may be used, selecting one corresponding in size and form to the general contour of the jaw. This cup will be found too short at the posterior edge to receive the soft palate, but it may be extended by the addition of a piece of sheet gutta-percha, which must be molded into such form as not to impinge upon the soft palate, but which will reach under and beyond the uvula, and thus protect the throat from any droppings of plaster. Before using the plaster, the posterior edge of the gutta-percha extension may be softened by heat and introduced into the mouth. Contact with the soft palate will cause it to yield, so that there is no danger of its forcing away the soft tissues when the plaster is used. The first effort will be to get only the lingual surface, taking precaution not to use too much plaster. After trial, if the impression show definitely the entire border of the fissure, and the soft palate has not been pushed up by the spasmodic action of the levator muscles, it is all that is thus far desired. If, however, the soft parts have been disturbed (which, on close comparison, a little experience will decide), it is better to take a model from the impression; and from this model extemporize an impression cup, as described on page 1139. This temporary cup will have the advantage of the former, inasmuch as it requires but a thin film of plaster to accomplish the result, thus lessening the danger of disturbing the soft tissues. After the removal, if it is seen that any surplus has projected through the fissure and spread out over the floor of the nares, it should be trimmed off.

In most cases such an impression will be all that is required. Such an impression can be taken, with a little experience, quite as readily as a correct impression for a set of teeth. The all-important point is to have the border of the fissure closely defined, with the soft parts hanging in their *relaxed condition*. It is not essential to one of experience that the pharynx behind the uvula should be taken in the impression. When the model is obtained from the impression, a representation of the pharynx can be made, with sufficient accuracy for practical purposes, by carving. It is only when the floor of the nares is used for the support of the palate that it becomes necessary to obtain a more complicated impression, one which shall represent not only a portion of the buccal cavity, but all the superjacent nasal cavity. When this is required, the next step will be to obtain, in conjunction with this impression of the under surface (which we call the palatal impression), an impression of the upper or nasal surface of the hard palate. This can be done by filling the cavity above the roof of the mouth with soft plaster down to the border of the fissure, and while yet very soft, immediately carrying the palatal impression against it and retaining it in that position until the plaster is hard, which can be easily ascertained by the remains in the vessel from which it was taken. Taking the precaution to paint the surface of the palatal impression with a solution of soap, to prevent the two masses from adhering when brought in contact, there will be no difficulty in removing it from the mouth, leaving the mass which forms the nasal portion *in situ*. With a suitable pair of tweezers this mass is easily carried backward and withdrawn from the mouth; the irregular surface of contact indicates its relation to its fellow when brought together.

Fig. 1231 will show such an impression. The portion marked A, B, C will readily be distinguished as that which entered the nasal cavity. The line of separation from the palatal impression is plainly indicated in the engraving. The groove marked D shows clearly the impression made by the delicate uvula in the soft plaster. The nasal portion is relatively large, showing an unusually large nasal cavity. The vomer lies between the projections marked A, A, these projections entering the nasal passages. The surfaces marked B, B, come in contact with the middle turbinated bones; the surface marked C, in contact with the inferior

FIG. 1231.

turbinated bone. In many instances these turbinated bones are so large as to nearly to fill the nasal passages.

The method of obtaining a model of the mouth from this impression does not require any particular description. The process is similar to the making of a cast into any other mouth impression. The model represented in Fig. 1230 shows a convenient form for such a case.

When the nasal portion of the impression does not indicate the superior surface of the soft palate, the part may be represented in the model by carving. It is not essential to the success of the artificial palate that the posterior surface of the soft palate should be represented with the same accuracy that is required on the inferior surface or on both surfaces of the hard palate. By the aid of a small mirror and a blunt probe the thickness of the velum and the depth behind the fissure can be ascertained; approximate accuracy is sufficient, since the portion of the artificial palate coming in contact with it is so elastic that it easily adapts itself to a slight inequality, rendering absolute accuracy less important.

The next step will be the formation of a model or pattern of the palate. Sheet gutta-percha is preferable for this purpose, although wax or some other plastic substance might answer. The form which should be given is better indicated by the drawing, Figs. 1225 and 1237, than it could be by written description. The Stearns instrument, of which a cut is here given (Figs. 1233 and 1234), was made to embrace the edges of the fissure and was slit up through the middle, so that when the edges of the fissure approached each other, as they always do in swallowing, the two halves of the instrument would slide by each other; a third flap or tongue was made and supported by a gold spring, to cover and keep closed this central slit.

Fig. 1232 shows Dr. Kingsley's original artificial velum, conceived to meet the requirement for a more simple contrivance than the complicated Stearns instrument. It is said that Dr. Stearn before his death abandoned his complex apparatus, and was wearing one made upon the same plan as Dr. Kingsley's.

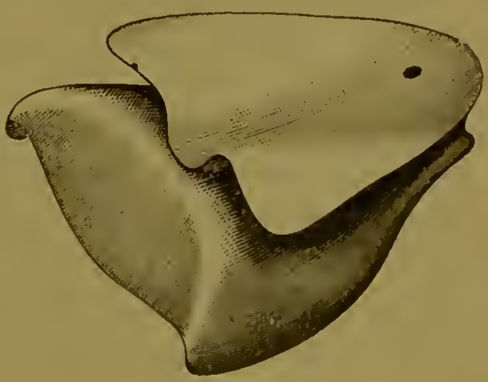


FIG. 1232.

Stearn's complicated provision for the contraction of the fissure is entirely superseded in Figs. 1225 and 1237 by making the instrument somewhat in the form of two leaves, one to lie on the inferior and the other upon the superior surface of the palate, and joined together along the median line. When the fissure contracts, the halves of the divided

uvula slide toward each other between these two leaves. The posterior portion, marked A, in Fig. 1225, is made very thin and delicate on all its edges, as it occupies the chamber of the pharynx, and is subject to constant muscular movement. The sides are rolled slightly upward, while the posterior end is curved downward. The inferior portion, marked D, D, should reach only to the base of the uvula, and bridge directly across the chasm at this point (Fig. 1226); and no effort to imitate the uvula should be made. The extreme posterior end should not reach the posterior wall of the pharynx by a quarter of an inch when all the muscles are relaxed (although subsequent use must determine whether to increase or diminish this space), thus leaving abundant room for respiration and for the passage of nasal sounds. In cases

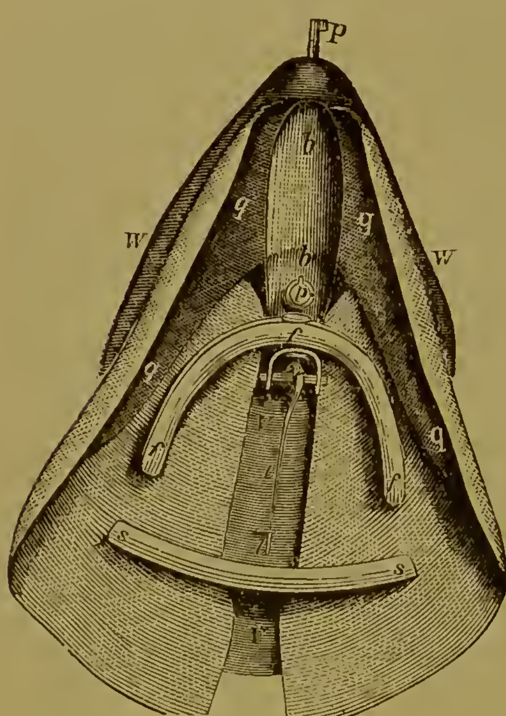


Fig. 1233.

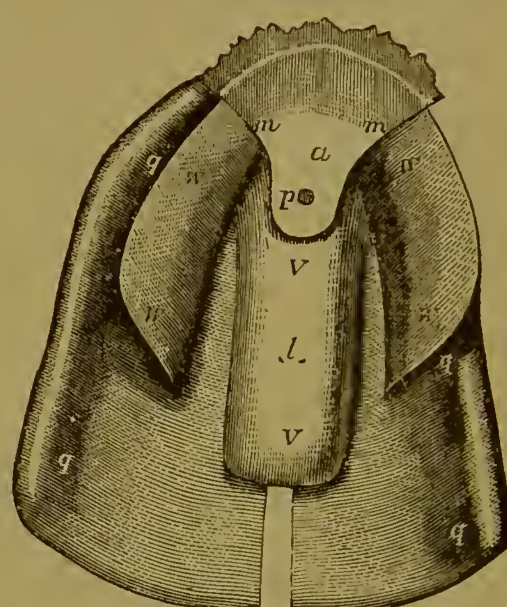


Fig. 1234.

where it is desirable to make the instrument, as far as possible, independent of the teeth for its support, the anterior part which occupies the apex of the fissure in the hard palate may lap over upon the floor of one or both nares. Such a projection is seen in Fig 1225, marked B, and a like process is seen in Fig. 1237, but not lettered. Were it not for this process in the first case, the palate would drop from the fissure into the mouth, the single clasp at the extreme anterior edge not being sufficient to keep the whole appliance in place throughout its entire length. Caution must be exercised that this projection entering the nares be not too large, or it will obstruct the passage, and give a disagreeable nasal tone to the voice.

All the peculiarities described must be provided for in the gutta-percha model, which after having been carefully formed upon the cast, may be tried in the mouth, to ascertain its length or necessary variations. When its ultimate form has been determined, provision must be made to duplicate it in soft rubber. A familiar illustration of the process here to be adopted is found in the parallel process employed when a set of teeth is made on the vulcanite base. A model form is made of wax and gutta-percha, bearing the teeth, and in all its prominent characteristics has the shape desired in the completed denture, the rubber duplicate being vulcanized in a plaster mold. In like manner the rubber duplicate of the palate, as before described, may be made in a plaster mold.

If plaster is used for the molds, it must be worked so that the surface shall be free from air bubbles, or the rubber palate will be covered with

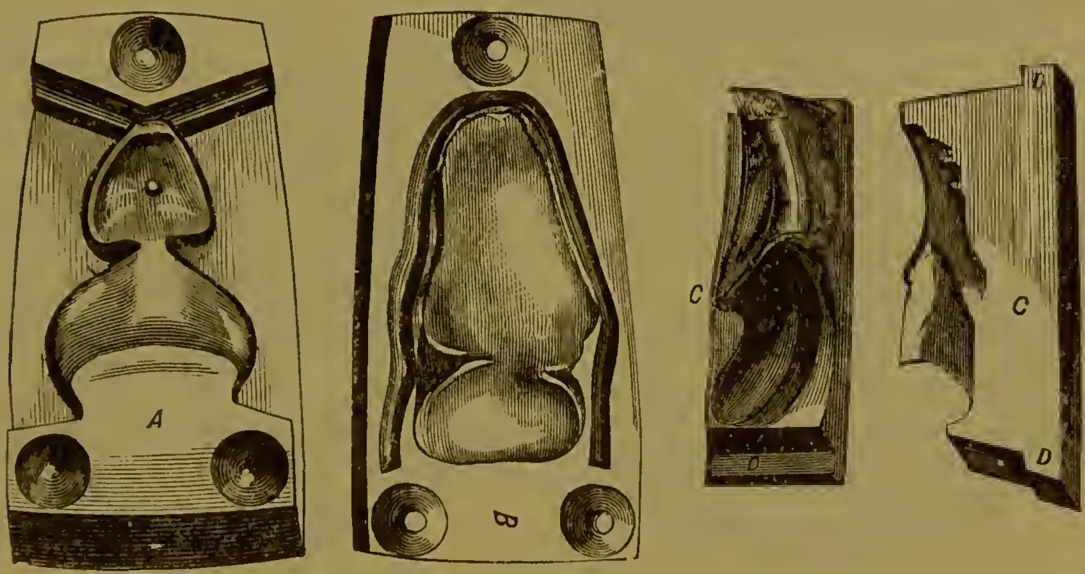


FIG. 1235.

excrescences that cannot readily be removed. By covering the surface of the mold with collodion or liquid silex, it will be much improved. But, ordinarily, plaster molds will be found too troublesome for general use. They may be put to a most excellent use, however, by using one to make a duplicate of the gutta-percha in hard rubber. This is not necessary with those who have had much experience, but with beginners it will be difficult to work up the gutta-percha as nicely as may be desired; a duplicate in vulcanite will enable the operator to make a more artistic model of the palate, and one which can be handled with greater freedom.

As in the course of a lifetime a considerable number of elastic palates will be required, the mold which produces them should be made of some durable material. The type metal of commerce is admirably adapted to this use. A very complete mold is one made of

four pieces which will produce a palate in one continuous piece. Such a mold requires very nice mechanical skill in fitting all the parts accurately, and unless the operator has had experience in such a direction it is better to simplify the matter. Fig. 1235 shows a mold in four pieces. The blocks, C, C, are accurately adapted to the body of the mold marked A, and are prevented from coming into inaccurate contact with each other by the flanges, D, D, which overlap and rest upon the sides of the main piece. B, shows the top of the mold, and the groove, E, provides for the surplus rubber in packing. Such a mold makes as perfect an appliance as can be produced. The palate is one homogeneous and inseparable piece. The cut will sufficiently indicate the form of the several parts. Each of these pieces is first made in plaster, having exactly the form desired in the type metal. They are then molded in sand, and the type metal cast as in making an ordinary die for swaging. When in use a clamp similar to Fig. 1236 is placed around the mold to keep the several parts firm in their position.

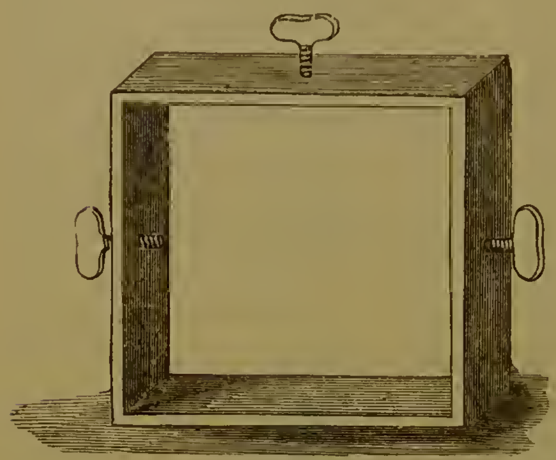


FIG. 1236.

Fig. 1237 shows the palate complete with its attachment to the teeth. The palate is secured to the plate by a pin of gold passing through a hole of the same size in the palate, the head on the pin being larger than the hole through which it is forced.

FIG. 1237.

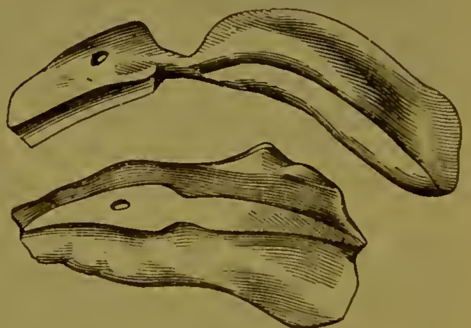


FIG. 1238.

By making the palate in two pieces to be joined after vulcanizing, as shown in Fig. 1238, the mold may be made in only two pieces and with very little trouble. When in use the two pieces, as here represented, are bound together at the forward part by the gold pin

before referred to, and a few stitches of silk secure it at the posterior part.

The instrument then becomes identical with that shown in Fig. 1237.

Fig. 1239 shows the mold or flask in which it is vulcanized. These flasks were made expressly for this purpose; but they are not so unlike the flasks in common use in dentists' laboratories that the latter will not answer. The common flask is simply unnecessarily thick or deep.

The mold is readily produced in the following manner: Imbed the two pieces of the palate in the plaster in one-half of the flask; when the plaster is set and trimmed into form, duplicate it in type-metal by removing the palate, varnishing the surface, molding in sand, and casting. In making the sand mold, take a ring of sheet iron of the same diameter as the flask and three or four inches high; slip it over

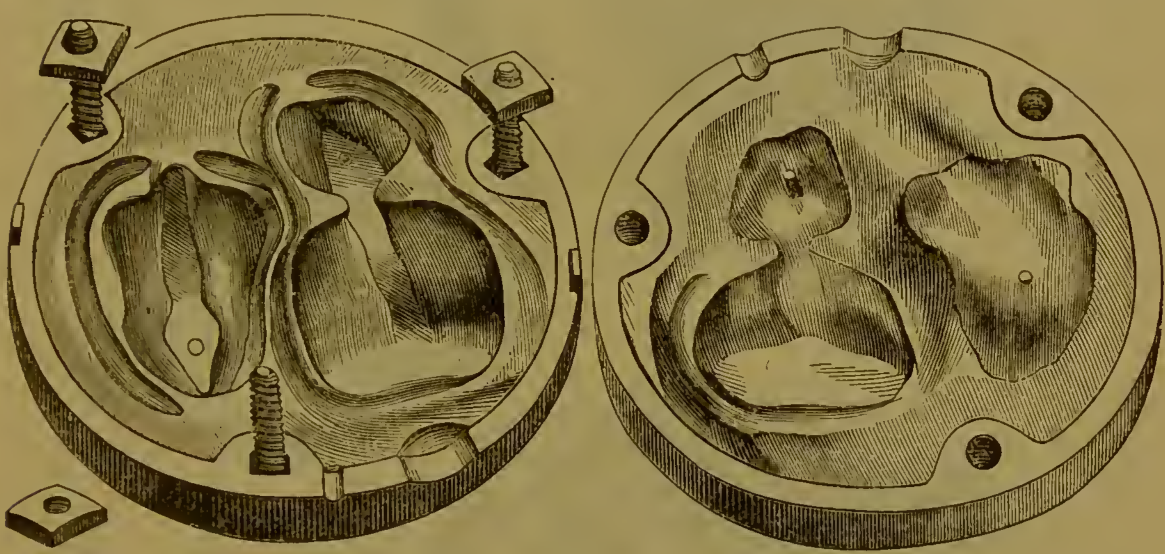


FIG. 1239.

the flask and pack full of sand. Separate them, remove the plaster, return the flask to the sand mold, and fill with the melted metal through a hole made in the side or bottom of the flask. Having thus made one-half, substantially the same process will produce the counterpart.

Fig. 1240 shows the mold which produces the palate illustrated by Fig. 1227. It is the most simple and at the same time the most complete of any mold yet invented. The mold is made in three pieces, and is inclosed in a flask exactly the same as Fig. 1239, but with this improvement: the latter mold yields a piece formed of two separate parts of rubber, which must be afterward joined by stitching or otherwise; while the former (Fig. 1240) produces an appliance in one piece, and as perfectly finished as by the more complicated mold of four pieces, shown in Fig. 1235. Letter A, represents the base of the mold;

B, the middle section, which is placed on the top of A ; and the third section, or top, C, completes it.

The mechanical process by which this mold is made is substantially the same as given for making those before described. The packing of the mold with rubber should be done in the same manner as when hard rubber is used for a dental base, with which process it is assumed that the reader is familiar. By washing the surface of the mold with

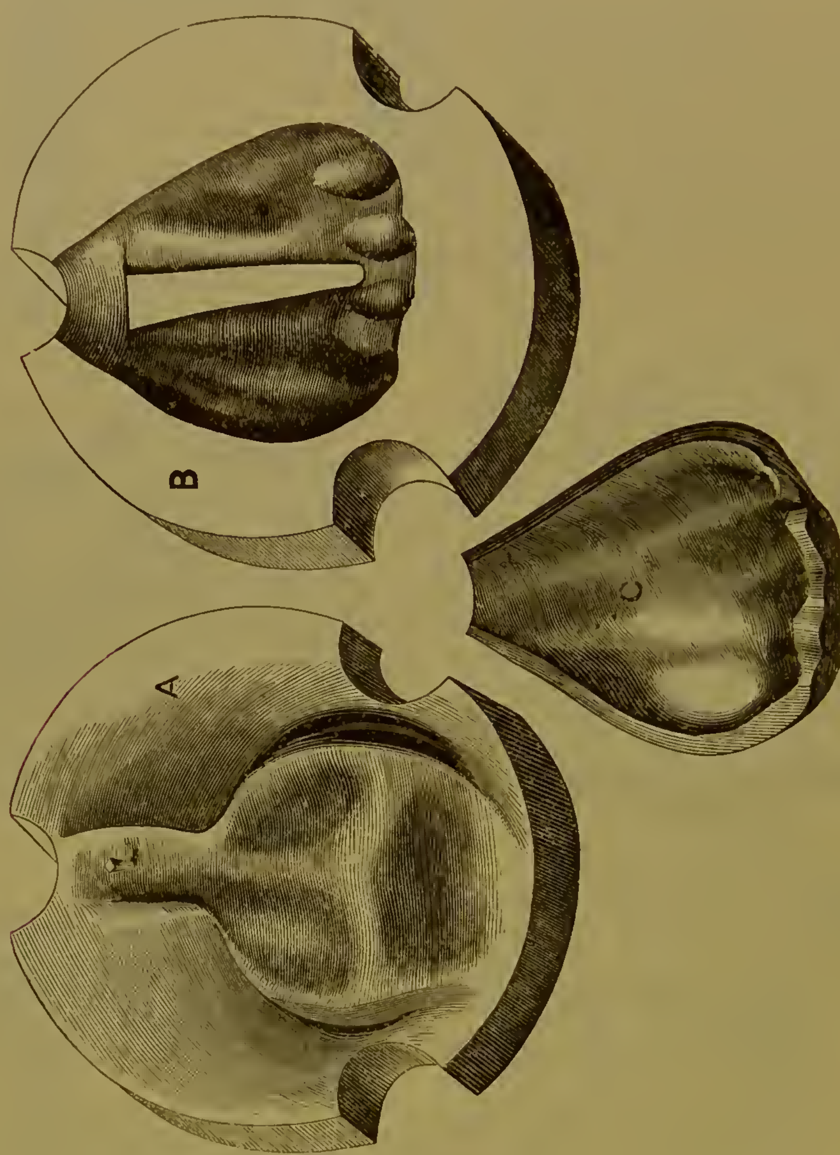


Fig. 1240.

a thick solution of soap previous to packing, the palate will be more easily removed after vulcanizing. The rubber used for this purpose must be a more elastic compound than that for a dental base-plate. The composition used for the elastic fabrics of commerce will answer, if made of selected materials. There is also on sale at the dental depots a soft, elastic compound admirably adapted to the purpose, with accompanying instructions for vulcanizing ; the best results being

obtained by heating up to 230°, and gradually increasing during four or five hours to 270°.

The following article on the treatment and education of Cleft-Palate Patients by Dr. Norman W. Kingsley is both interesting and instructive:*—

"The only necessity for interference, in congenital cleft-palate cases, is to remedy the defective speech.

"From time to time it has been asserted that the difficulties which the patient met with in deglutition would justify a surgical operation, but this is a mistake. Long before the child has reached maturity he has learned to accommodate himself to his unfortunate condition, and has acquired the habit of swallowing so well that it does not cause him embarrassment.

"There is no other evil attending cleft palate except the difficulty of articulate speech, and this does not lie in the fact that one *cannot* articulate, but only that his articulation is necessarily different from that of people who have normal organs of speech.

"The fault is not defective vocal organs, because the vocal organs are always as well formed, and in themselves as capable of perfect speech, as those of the rest of mankind. The difficulty arises from the inability of the patient to manipulate his voice in the production of the consonants, which form so large a part of spoken language. With the exception of intonation, the vowel sounds of articulate language are comparatively pure in these cases.

"The effect, however, of an inability to articulate many consonants renders the speech in some instances quite unintelligible, and in all cases very disagreeable. But if all people were born with cleft palates, there would be no defective speech. The speech of mankind would then be made without the introduction of certain consonants, which now form a distinguishing part of all languages. Thus we see that articulate speech is not a normal function, but an acquirement of man as he evolved from an original speechless condition.

"For treatment of congenital cleft palate both surgery and mechanism have been resorted to. Surgery was naturally first suggested. As operators became more and more skilled in their art, it was but reasonable to suppose that a complete surgical union of the split palate would cure the obvious evil. Staphylorrhaphy first became famous about the year 1820, through the skill of an American surgeon, Dr. Warren, of Boston. For many years thereafter the operation was regarded as one requiring unusual skill, and it became a favorite with ambitious surgeons desirous of distinction.

* *Dental Cosmos*, February, 1894.

"But surgery, after a full trial under the advantages of the most skilled artists for more than half a century, has disappointed expectations.

"The cases are very exceptional where normal articulation is ever acquired with a surgical velum. To understand the reason involves a knowledge of the mechanism of speech; a knowledge of the positions which normal organs assume in the formation of consonant sounds. The palate plays an important part in this function. It serves to close the passage to the nasal cavity and to the buccal cavity, and also to split the voice as it issues from the larynx. Each of these oper-

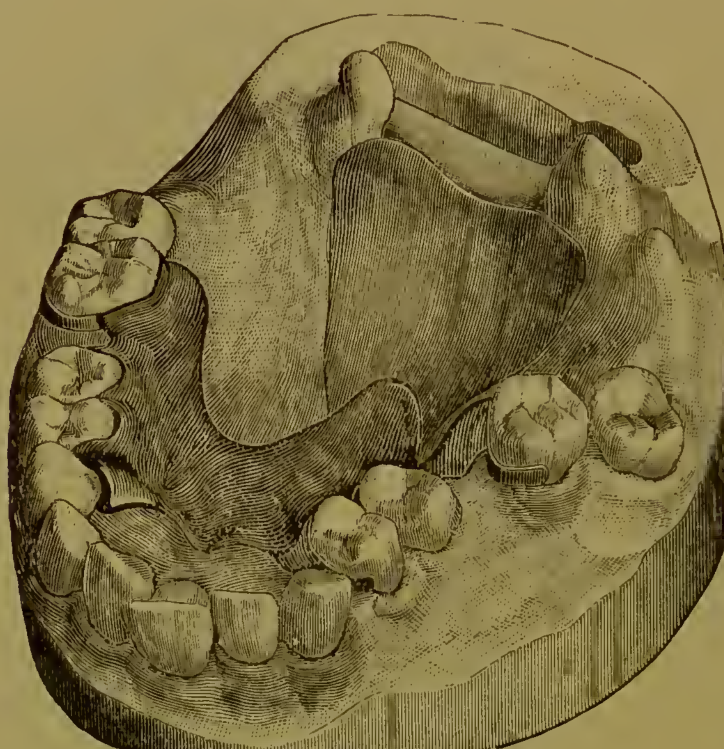


FIG. 1241.

ations changes the voice, thus producing different sounds, which form an essential part of all languages.

"The surgical palate is incapable of all these actions. In many instances it is so tense and so short that it appears to be more of an interference than a benefit. Besides, surgery is limited in its application. No prudent surgeon would attempt to operate without what he regarded as an abundance of tissue, with which to bridge over the gap. Thus are excluded a large number of cases involving extensive fissures of the hard palate, for which surgery can find no remedy.

"Mechanism, with all its objections, has produced the best results. Appliances are made sometimes flexible, or elastic, and sometimes rigid, or non-elastic. Flexible instruments have been made which

perform measurably the physical functions, and quite fully the physiological functions, of the natural velum. Rigid appliances (obturators), while not performing the physical functions, nevertheless, in many instances, perform the physiological functions of articulation equally well. Any one who has had long experience in making such

FIG. 1242.

instruments, and noting the effects of both sorts of apparatus, will have seen abundant evidence that *neither kind of instrument is the best in all cases.* Each has its advantages, and there are objections to the universal application of either.

"I make a distinction in name between the two kinds of appli-

FIG. 1243.

ances. Flexible instruments are "artificial vela;" non-elastic instruments are "obturators." Figs. 1241 and 1242 show the former, Figs. 1243 and 1244 the latter.

"In the hands of a skillful artist of long experience, the flexible

instrument is undoubtedly the best with which to *acquire* articulation, and were it not for the perishable nature of the material of which it is made, there is no case in which it should not be preferred. It imitates the form and action of the natural velum quite as well as artificial teeth imitate the shape of natural teeth and perform the function of mastication, and with it one can learn to articulate more readily than with an obturator.

"Obturators are simply plugs filling up to a greater or less extent the upper pharynx or the posterior nares. When properly adapted they are especially valuable to supplement the use of an artificial velum, and in many cases their use would be justified as a primary instrument.

"No rule can be given, or description made, which will indicate to the inexperienced which sort of apparatus is likely to confer the most help in any case. No study of a model of the parts involved will be of much advantage. It is only the experienced eye, watching the action of the muscular tissues in the remainder of the palate and of the superior pharynx, which will guide to a determination.

FIG. 1244.

"Nor is it at all possible, by observation of such action, to form any opinion of the effect upon the speech. That can be known only by hearing. With a personal experience of more than thirty years, and an observation of more than a thousand cases, I have failed to discover *all* the causes which are in force in producing mal-articulation. It is easy to discern physical causes, but the esoteric physiological causes are so remote that to me they still continue to be a mystery.

"I have seen horrible deformities in the absence of the velum, the hard palate, and all the anterior part of the alveolar arch, including also the upper lip, where the speech was absolutely unintelligible. Fig. 1245 represents the model of such a case. Here the inexperienced would readily find a cause for the mal-articulation. But I have seen very small clefts, fissures of the velum only, nasal passages normal, neither vomer, turbinated, nor palatal bones abnormal, and no harelip, where the speech was as defective as in the former case. Fig. 1246 represents one of the latter class.

"I have also seen an extensive fissure, involving hard and soft palates, a portion of the alveolar process, and a harelip, where but that the lip directed attention to the possibility of a palatal cleft, such

a deformity would not have been suspected from the speech, except by the most critical ear. For ordinary purposes of life, and to the aver-

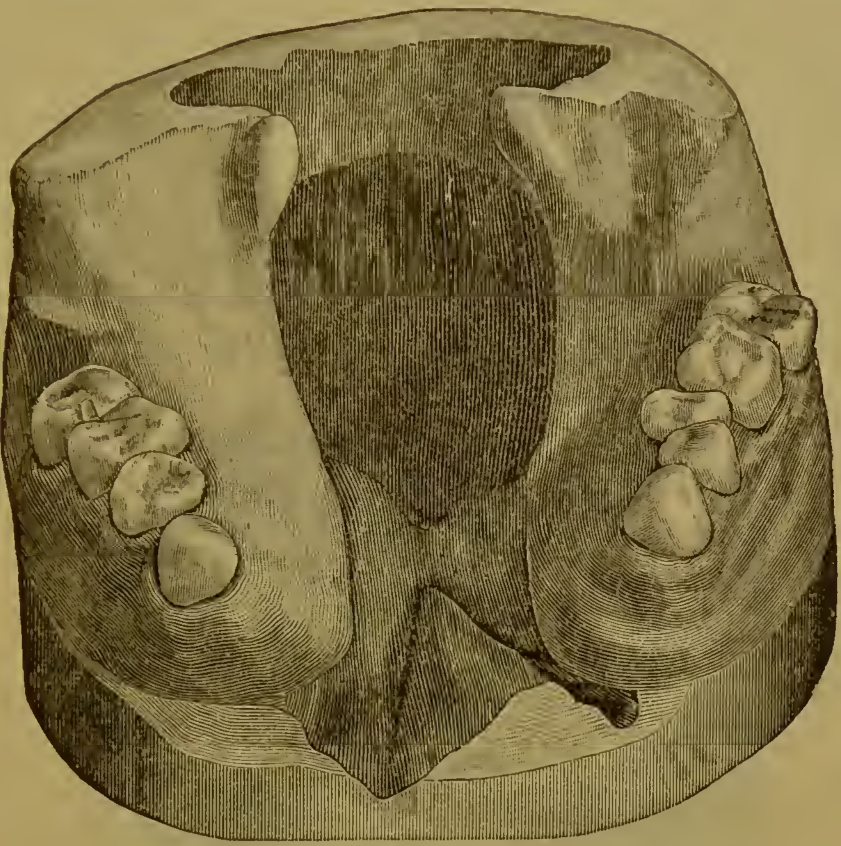


FIG. 1245.

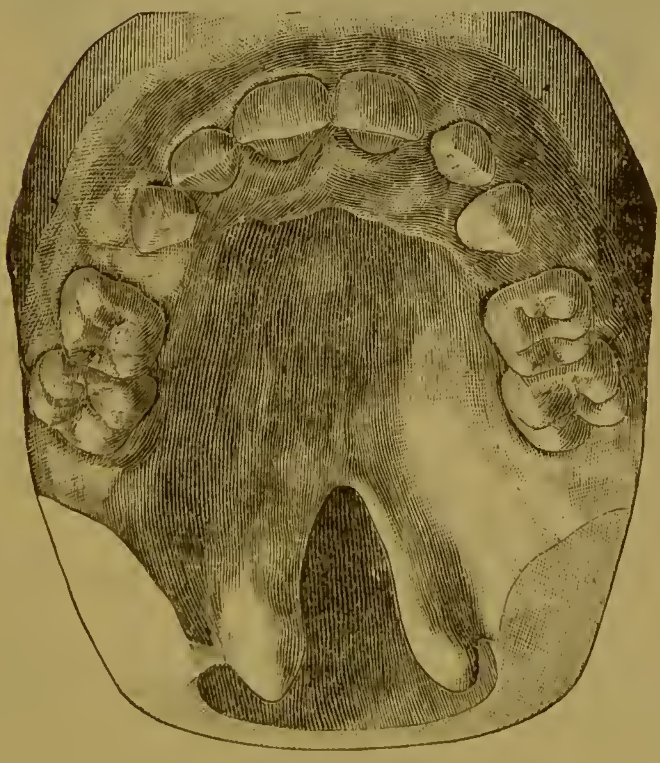


FIG. 1246.

age listener, the speech was good. The only admixture was an occa-

sional guttural sound, which does not belong to pure English. Fig. 1247 is the model of that case.

"Where a cleft palate does not reach the alveolar border, there is no apparent anatomical reason why the sound of "s" should almost invariably be absent; but it is a fact; and there is every anatomical reason apparently in all clefts for the inability to form the sounds of "k" and "g;" yet I have heard these sounds made with great distinctness, *without an instrument*, and without special training. Such cases, however, are very rare. The possession of an apparatus, of whatever nature, however cunningly conceived and skillfully adjusted to the needs of the patient, will not transform him immediately into a

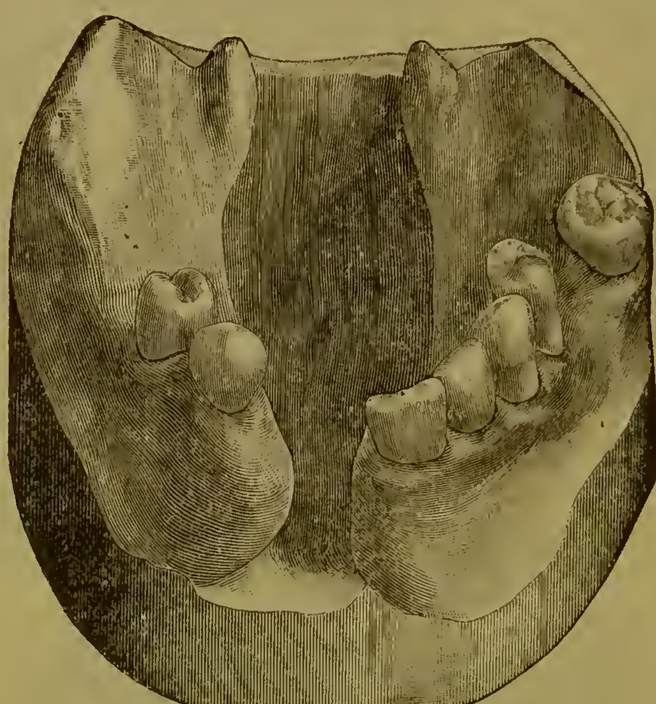


FIG. 1247.

perfectly speaking person, any more than would the possession of a violin transform the possessor into a master of that instrument.

"Articulate speech is an acquired function, and, being an acquirement, involves application and practice. An acquirement which so pre-eminently involves mental application must depend for its success largely upon the mental attitude of the applicant, and demands natural aptitude, as well as desire, determination, and perseverance. It is an imposition upon the credulity of this deformed class of people, undergoing constant mortification from their defect and terribly anxious for relief, to hold out the encouragement that they will certainly obtain relief by simply wearing an instrument. It is quite possible, and even probable, that if an instrument could be applied in infancy, the same faculty which enables the child to learn, without special instruction,

to speak with normal organs, would lead him to the same result with an artificial organ; but the people with whom we have to deal rarely come into our hands until early infancy has passed, and bad habits of speech have become almost fixed. The muscles involved in the mechanism of speech have acquired improper actions in their efforts to make up for their deficiency, and so it follows that the majority of people, upon the introduction of an artificial palate, are handicapped by the bad habits of speech which must be unlearned or overcome.

"After a somewhat lengthy experience, I am convinced that not more than one person in ten wearing an artificial palate (and I use the term now indiscriminately for both classes of instruments), having passed the age of childhood before its introduction, will *of his own volition* attain such perfection of articulation and enunciation that he does not betray his defect; while I also know that there are innumerable instances of persons who have reached mature age before they began their work of correction, who, *under proper instruction* and with perseverance, have attained absolute perfection.

"The imperative need of instruction was recognized by me in the earlier part of my practice, and from time to time I referred patients to teachers of elocution for help. The result was not always satisfactory. Most of such teachers placed more importance upon *elocution* than upon *articulation*, and although some of the pupils made wonderful progress in articulation, I was not altogether satisfied with the methods of instruction.

"For the last ten years or more there has been associated with me in my practice a lady who possesses, besides other accomplishments of education, a vocal and elocutionary training. She conceived the idea of formulating a system of teaching articulation to cleft-palate people which might be denominated 'a system of vocal gymnastics,' based upon the methods used in teaching elocution and in teaching deaf mutes to articulate. Her system is not one of fixed and rigid rules. It is not one that could be taught in books, but it is one of general principles, varied in its application to the idiosyncrasies of each case.

"As the result of having such an able coadjutor, of late years I have insisted that it would be almost useless for me to make an apparatus for any patient unless my work could be supplemented by proper instruction; and, furthermore, I have carried this denial to the extent of refusing to make an apparatus for any one whose apparent mental condition showed an incapacity for study and improvement.

"The results under such tuition as indicated have sometimes been rapid and marvelous.

"A lady, about twenty-five years of age, from a distant State, applied to me. She carried in her appearance evidence of intellect and good

breeding, but there was a certain hopelessness in her countenance, bordering on despair. Her case was not unlike many others, and, fortunately for her, there was no harelip to disfigure a rather handsome face. Her speech was the speech of the average cleft-palate patient, but she was very averse to talking, and brought a companion to speak for her. The arrangements were made for me to do my work, and for her to go under tuition.

"Before I had made much progress, her morbid condition impressed me so much that I spoke to her of it. I told her that to me it betrayed unmistakable evidence that she had no hope that she would receive benefit. She then told me that she had little or no faith in the result; that an effort had been made two or three times before, both by surgery and by mechanism, but all had failed; that she was of an exceedingly sensitive nature, and had avoided all society; that she had neglected her education because of her deformity; and that she had come to me as a final resort, with the determination that if this failed she would never return to her family, but would find some way to end all her troubles.

"I told her that it was almost useless for me to go on, unless she made an effort to throw off that condition and assume one of expectation of relief; that I could promise her, with absolute certainty, great benefit, if my directions were faithfully carried out.

"Suffice it to say that while at first she seemed incapable under tuition of comprehending what she was taught and directed to do, because her faculties had been dormant through neglected education, nevertheless she shortly began to rouse herself, and made progress.

"I lost sight of her for three months, during a summer's vacation, and on my return was astounded at the change. She was speaking exceedingly well, her face was brilliant with joy and gratitude, and she fully realized that there was something in life for her; that life was worth living.

"It has been generally supposed that a child with a congenital cleft must wait until the jaw and alveolar arch were pretty fully developed, or until about the twelfth year of age, before it was prudent to apply an artificial palate. I favored that idea myself many years ago, partly because I wished to avoid the annoyance to which the child might be submitted, and partly to save the expense of a second apparatus when the child should become older.

"My first use of such an appliance for a child was in January, 1865. It was for a boy eight years of age, who was nervous and irritable, and the results discouraged me.

"But the experience of many cases since has convinced me that my hesitation was a mistake. The advantages gained by an early inter-

ference far outweigh any financial considerations, and I find that children become accustomed to the presence of such a foreign body quite as readily as adults.

"The benefit to be gained by preventing improper efforts at articulation from becoming fixed habits, as well as the greater ease with which habits already formed can be broken up, must be manifest to every one. Children adopt involuntarily the tone of voice, accent, and peculiarities of utterance of those with whom they are associated, and I am satisfied that perfect results are attained more rapidly and with less effort by supplying an artificial velum early in life.

"A little girl seven years of age was brought to me. She had a harelip, which had been closed by a very fair operation, but leaving one nostril much more open than the other. I recommended a supplementary operation for reducing the size of that nostril, because I have found that an excessively open nostril, in such cases, makes articulation more difficult, besides altering the tone of the voice.

"For this child I made an artificial velum, and she was put under training. This training was an hour's lesson three times a week, the practice to be kept up under the care of her governess. The tuition continued for three months, after which the child was, by the removal of the parents, taken beyond the reach of her teacher. Within a year she was speaking quite as clearly as the children of her age, and the nasal resonance peculiar to such cases had entirely disappeared. During the following year, before she was nine years of age, her parents were spending the summer at a noted fashionable resort, and the child was placed in a select private school. She had learned to keep the fact secret that she was wearing an artificial palate, and her speech in nowise betrayed her. After a time her school-teacher came to her mother, and inquired if the child had ever had any special attention given to her enunciation, because, said she, "she speaks so much more clearly and precisely than other children, that I thought she must have had some special training."

"Another instance of a peculiarly interesting nature is that of a child six years of age. The model of this case is shown in Fig. 1248.

"I hesitated very much about undertaking this case, because of the difficulty of finding anything to which I could secure an artificial palate. The crowns of all the deciduous teeth in her mouth, except one, had decayed off level with the gums, and the first permanent molars had not erupted. But the mother of the child was persistent, and I made an artificial velum, clasping the fairly whole crown of a temporary molar on one side, and putting a gold crown on the remainder of its mate on the other side of the jaw, to which the second clasp was fitted. This child was for three months under the care of my teacher of articulation. She was formally given a short lesson

twice a day, and informally kept up a more or less continuous practice. She had never learned to read, not even knowing the letters of the alphabet. At the end of three months she could read simple lessons with ease, and her articulation was as faultless as that of the best children of her age. Previous to the beginning of this child's training her imperfect speech was recorded by a phonograph.*

"The next case, shown in Fig. 1246, is one of especial interest. The fissure is very small,—one of the smallest that I have ever attempted to treat. It would probably have encouraged the average surgeon to undertake an operation if he overlooked the fact which I have frequently pointed out,—viz, *that even with the gap in the velum perfectly closed there would still be a gap between it and the pharyngeal wall, which could not be bridged across except by an appliance; and,*

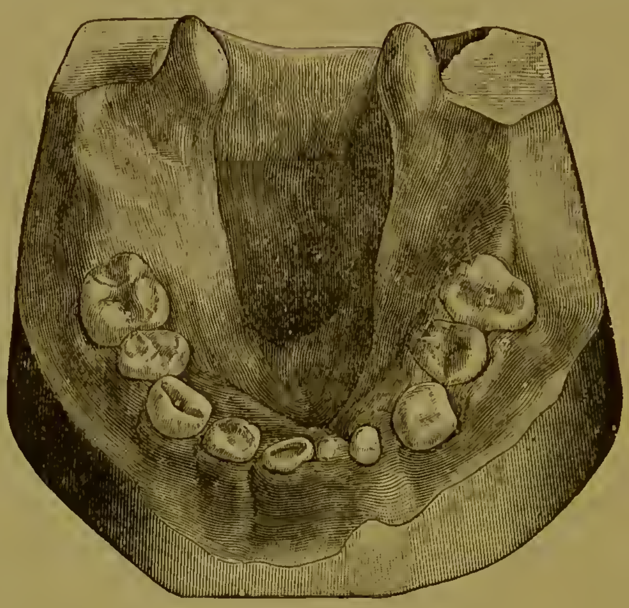


FIG. 1249.

furthermore, if the split in the velum were surgically closed, it would prevent the introduction of a suitable apparatus.

"In this case, notwithstanding the smallness of the fissure, the speech was about as bad as bad could be.

"This was a lad about ten years old, and to publicly prove his malarticulation I took him before one of the medical societies in New York, and submitted him to the following test: I gave to each person in the audience a piece of paper, upon which were thirty-four blank spaces numbered from one to thirty-four consecutively. I held in my hand a printed slip, on which were thirty-four words.

"I asked the lad to pronounce loudly, and with as much distinctness as possible for him, the word against each number as I pointed to it.

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* At the time of this writing, one year after the introduction of the instrument, I have seen the child, and her speech is without defect.—N. W. K.

As he did so I requested the audience to write on the slips against the same number their interpretation of what they heard. The advantage of this test lay in the fact that the auditors had no clue to the coming words, and therefore were guided solely by their hearing. The lad was repeatedly asked to repeat the words, and in the end the slips written by the audience were compared with the printed slip held by me. Many of the records showed that not a single word had reached the writer correctly, and in no instance had more than five of the whole list been fully understood.

FIG. 1249.

"The instrument which I made for this lad is illustrated by Fig. 1249, and its position when in the mouth is seen in Fig. 1250. By an observation of Fig. 1246 it will be seen that the apex of the cleft is only about half-way from the uvula to the junction of the hard and soft palates.

FIG. 1250.

"To accommodate considerable vertical movement in the unruptured portion of the natural velum, the instrument is hinged at the posterior border of the palatal bone, so that ample provision is made for the vertical movement of the artificial velum. The hinge is supplied with a stop to prevent the velum from dropping below the fissure, but it can be carried upward with ease."

INDEX.

Single references will be found under leading word of title; many subjects are referred to under each word of title, and sometimes under its synonym. Principal subjects are alphabetically arranged; but details and subdivisions are usually given in the order of description in the text, so as to present a full synopsis of the subjects indexed.